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GEORGE REID
Editor

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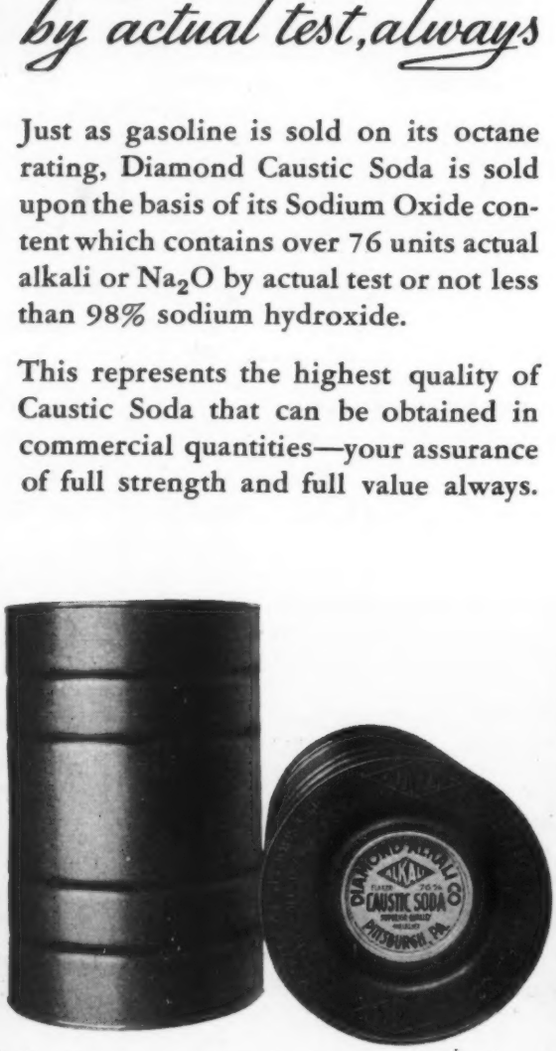

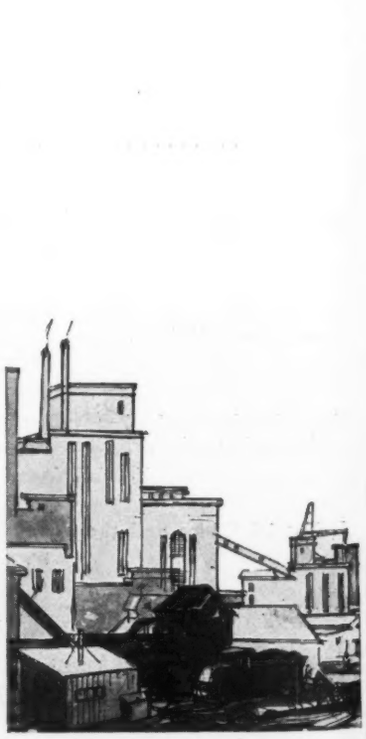

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REFINER
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VOLUME 13, No. 8 AUGUST, 1934

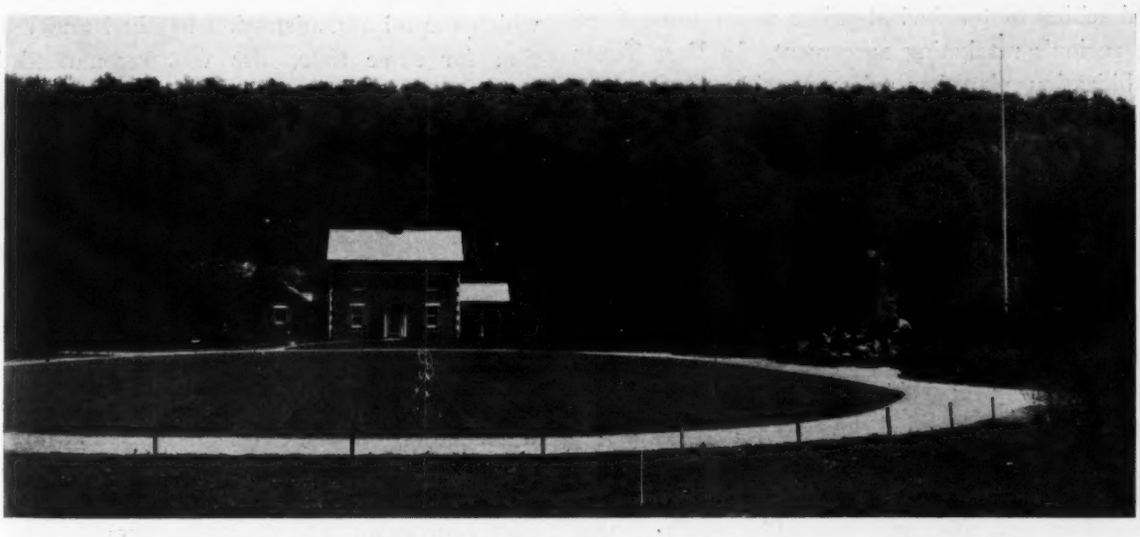
Diamond Jubilee This month at the Drake Memorial Park the petroleum industry celebrates its Diamond Jubilee; the seventy-fifth anniversary of the drilling of the first oil well. On August 24 oil men will gather at Titusville, the birth place of the industry, and for four days, through August 27, will be entertained by a well planned program of activities.

Drake Memorial park, several acres in extent, has been made possible by the citizens of Titusville and the American Petroleum Institute, which sponsored the raising of money for the erection of a caretaker's cottage and a suitable museum. The commonwealth of Pennsylvania will, on August 27, accept the park as state property.

Drake Memorial park is less than a mile from Titusville. It is located in a very beautiful site, the natural beauty of which has been greatly enhanced by the care exercised in the selection of trees and shrubbery in the foundation planning. The Drake Memorial Museum, the largest building of the group, is one of the finest small museums in the state, and the architecture is pleasing and dignified. This is the only museum in the world dedicated exclusively to the preservation of oil field historical data, records and equipment.

On August 27, 1859, Col. E. L. Drake completed drilling the first oil well at 69½ feet and it started flowing oil worth $1.00 a gallon, at the rate of 40 barrels per day. It is fitting that the site of this first well should be permanently preserved; as it is fitting that oil men should gather at the site this month and partake in the industry's Diamond Jubilee.

School Many oil companies conduct vocational training courses or schools by means of which their employes may better fit themselves for their positions, or may brush up on those things which slip away from one so speedily after leaving school. In Pennsylvania, the Penn State College offers extension courses, which in so far as they apply to petroleum and natural gas were first held in 1932-33. The courses and the methods under which they are conducted are discussed in this issue by G. O. Ebrey, chief chemist, Pennzoil Company. The courses are formulated and outlined by the Division of Mineral Industries Extension in collaboration with an advisory board consisting of men associated with petroleum production, refining and the natural gas industries.



Drake Memorial Park, Titusville, Pennsylvania. Site of the Diamond Jubilee of Oil. August 24 to 27.

Steam Pumps The presentation of graphical charts and discussions of the methods of preparation of such charts which have been published in THE REFINER have proven of interest and value. In this issue J. Y. Oleson shows the actual derivation of the equations to be used in preparing graphical charts showing the approximate steam consumption of various direct acting plunger pumps. Page 307.

Other Methods In a series of two articles by L. C. Trescott, dealing with possible application of hydrometallurgical methods to certain problems in refining petroleum distillates the author offers several suggestions which may prove beneficial. No criticism of present systems, processes and equipment is made nor intended, and the writer's views are entirely his own. If the discussion serves to point the way to any economies in the problems of separation, settling and agitation, it will have served its purpose well. Page 299.

Not Well Yet An improved gasoline market has been the result of stabilization plans inaugurated lately on the Pacific Coast and in East Texas; involving purchases of surplus gasoline by large companies from independent refiners, and obligation of the latter to process only legally produced crude. However, and despite the slight improvement the outlook is still clouded by uncertainties and difficulties centering chiefly around control of supply of gasoline and crude oil.

While the Pacific Coast and East Texas plans have stimulated gasoline prices there are indications that the programs may not prove wholly successful. In California some service stations and a few refineries are reported selling motor fuel at prices under those fixed in that region's marketing agreement. In East Texas the stabilization plan has taken considerable surplus gasoline off the market but "hot" oil is still being produced and refined into "hot" gasoline in large volume.

Some of the refiners have refused to participate in the East Texas plan; others are charged with violating their agreement to run only legally produced crude, and to observe gasoline production quotas allocated to plants by the code administration; and still others continue to form more companies, erect new refineries. Others attracted by reported quantities of topped crude at reported prices ranging below 50 cents per barrel are urged to act upon the stimulus of quick profits through erection of "cracking" plants. There is a scramble, however, for such topped crude, and that market is tightening. With shortage of the topped oil, prices should rise, and that form of enterprise become not so profitable. The new refineries and cracking plants are of course not parties to the marketing agreements.

California, during recent weeks, has also seen unusual activity in the construction of small independent refineries, especially around Long Beach and Hynes. Only a few give the appearance of intention of permanency through use of new equipment and facilities.

Indications give promise of an ultimate cure, but the patient is not well yet.

Price Wars As a major step in the general program to restore and stabilize the petroleum industry and to protect the independent, the oil administration today announced that the Planning and Coordination Committee had been authorized to establish local committees as needed to deal with local gasoline price wars and to negotiate settlements in the areas as the price wars arose.

In making public the plan, the oil administration called attention to the disastrous effects of retail price wars. They not only cause an excessive waste of oil and gasoline reserves, but they result in employes being worked long hours and their pay reduced to gain back some of the money lost by price cutting. In addition, large surpluses are piled up in the wholesale market and distributors are forced to sell for less than cost in efforts to unload heavy supplies at any price at which a buyer can be found.

Price wars are particularly disastrous to independents, both the wholesaler and retailer, who do not have the financial strength to stand the heavy losses suffered and may be bankrupted. This alone opens the way to monopoly because the larger companies have the financial reserves enabling them to take their losses and survive.

This policy for settling ruinous local price wars, which the oil administration has had under consideration for some time, also was recommended by the Darrow Board of Review in its report on the oil code. The plan stipulates that the settlements may be reviewed by the oil administrator and that they shall not in any way encourage the creation of a monopoly.

Exchange Apparatus W. L. Nelson, University of Tulsa, concludes his series of articles on the fouling of heat exchange apparatus. Various types of exchangers, coolers and the like are discussed, as are the various oils and the types of deposits which contribute to fouling. Recommendations are made in regard to care and maintenance of such equipment. The discussion should prove of value to those concerned with the design and operation of heat transfer apparatus. Page 292.

Stabilizer Operation

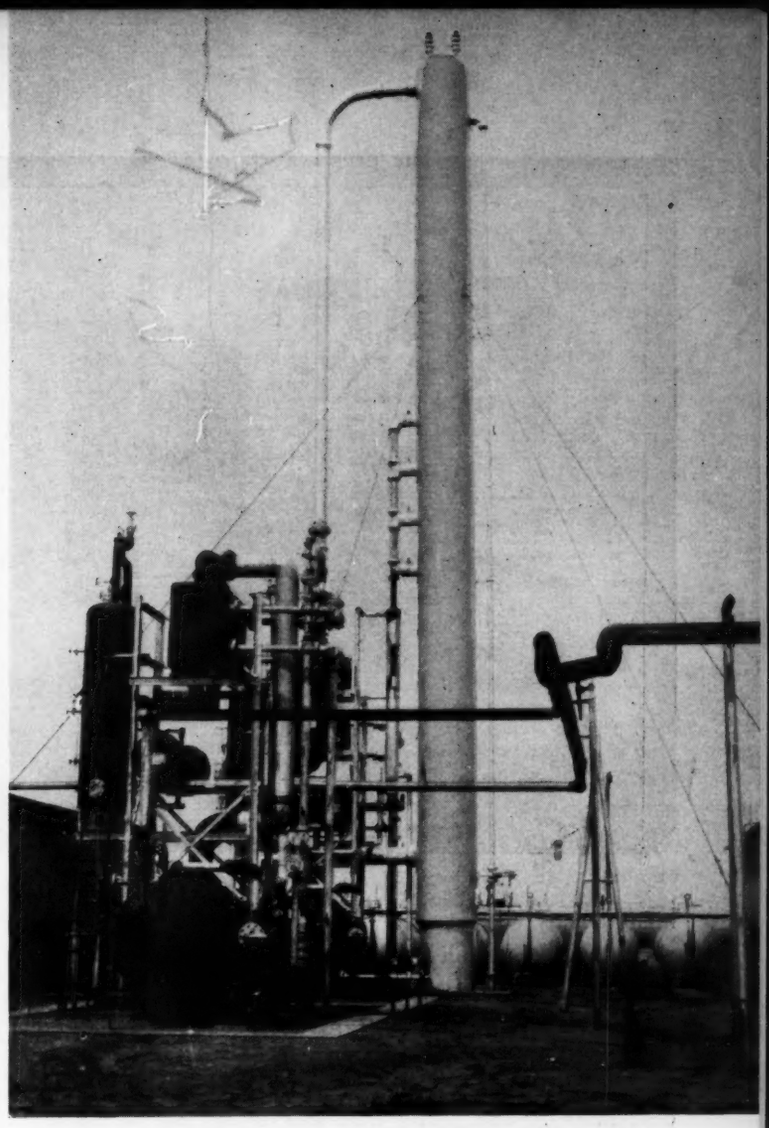
J. C. ALBRIGHT

DEVELOPMENT of the fractionator has progressed rapidly, and columns now are operated at many places so efficiently that practically a pure hydrocarbon can be separated from the composite make.

When a modern gasoline plant is built it is unusual not to include a fractionator; not particularly for the preparation of several close cut fractions, but for the purpose of removing only the lighter fractions without loss of more desirable ones. Some natural gasoline manufacturers include several columns in the stabilizing program. Others, with several plants in a general area erect the stabilizer battery at a central plant and pump the production from the others to this point. Oklahoma has several fields of major importance where a company is operating several plants. Indian Territory Illuminating Oil Company fractionates the bulk of its Oklahoma City production in one central battery but does not process for specialized cuts. Skelly Oil Company, Phillips Petroleum Company and Shell Petroleum Corporation operate plants in Northern Oklahoma and operate fractionator batteries both for the purpose of reducing the production of their plants to the various commercial grades and to manufacture special cuts. Lighter fluid, domestic bottled gas, aviation gasoline, rubber solvents and a variety of other pure cuts and combinations are produced. Various other manufacturers operate individual columns solely for the purpose of removing the propane and lighter components.

Propane is a product that has been marketed generally in areas not adjacent to gas fields or served by pipe line distribution, and is sold under various trade names. All of these domestic products are close cut propane, and the companies manufacturing them operate their columns in essentially the same manner. Some hold a constant column pressure while others vary the pressure and maintain a constant kettle temperature. There have been some interesting discussions relative to the proper manner of operating stabilizers, but after all, the product is what is required, and pure propane is pure propane, regardless of column pressure or reboiler temperature.

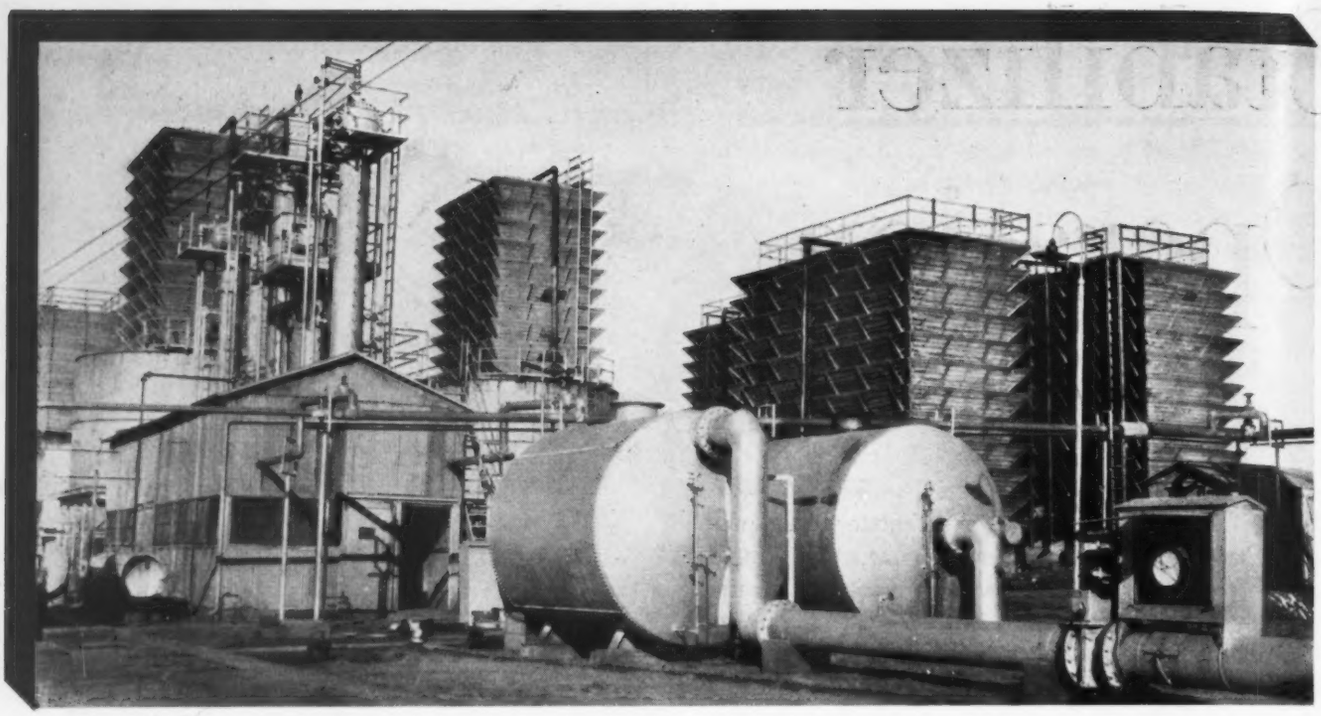
Skelly Oil Company's plant at Lyman, Oklahoma, in the northern end of the Burbank field in Osage County is equipped with three columns, all for a different purpose. The production of the Lyman plant is stabilized to 26/70 in the first column for the removal of all the propane and the necessary butane. The overhead stream is all condensed and utilized as reflux as needed for efficient column operation while the surplus is charged to the second column. This tower is utilized for the preparation of "Skelgas" and butane.



Skelly Oil Company's special tower with which all close cut fractions are manufactured from a 26/70 base.

The third column is a special tower through which all the close cut fractions are produced. This column is three feet in diameter by 60 feet in height, containing 30 plates with 18-inch spacing. The column is operated "batch," in that the contents of any 20,000 gallon storage tank is passed through for processing. Overhead vapors constitute the material for the manufacture of special cuts, while the base, or kettle product, is returned to storage for another processing later. Any produce, 26/70, 12-pound, aviation, or other grade may be manufactured by operating this special column, but it is generally operated in the manufacture of the finer cuts.

After this column was erected a series of experi-



Shell Petroleum Corporation's battery of special fractionation columns at Marshall, Oklahoma.

mental runs was made to determine what temperature should be maintained on the top plate, in the kettle, and the overhead vapor condensers to obtain the desired results. The rate of feed for the several grades charged to the column as well as the difference pressure had on the efficient separation of the cuts was also determined. One thing that was found out definitely and applied to all runs, was that column pressure must remain constant. It has been the practice generally in operating fractionators and stabilizer columns to regulate the back pressure by applying a regulator on the vapor line leading from the accumulator or run tank. A variation in pressure was found to exist caused by the variation of condenser water temperature, atmospheric conditions and the ease with which the product liquefied. This variation in column pressure was great enough at times to disturb the equilibrium of the tower and that resulted in impure cuts being removed through the overhead vapor line. To improve the operation of the column, an extra pressure regulating valve was installed in the vapor line near the condensers. With this valve operating, the pressure of the column can be controlled on a "straight line," and the quality of the product removed overhead remains constant.

No hard and fast set of operating rules can be applied to this column because of the changing composition of the feed. One day the product sent over to the battery from which the stock is drawn for the operation of this special column may contain more butane than at other times, and consequently the equilibrium of the column is brought about by a different set of temperature and pressure conditions. Again, when a particular cut has been removed and the remainder is charged to the column so that an entirely different fraction may be brought overhead, the temperature and pressures change again. The percentage of the various fractions present in the composite whole is another deciding factor in determining the operation of the column. By changing the pressure, rate of feed and temperature of the kettle, the reflux ratio and point of entry to the column, many different fractions and combination of fractions may be brought overhead and condensed in unvarying constancy of quality and quantity.

Shell Petroleum Corporation operates its battery at Marshall, Oklahoma, in series of six, singly or any combination of columns, depending upon the grade of product desired. The gasoline produced from the field nearby is similar to that produced at Burbank and is sweet and not requiring any great amount of treatment either before or after fractionation. By processing the production of the Marshall gasoline plant through this battery, the company makes a variety of special products; "Shellane," cigar and cigaret lighter fluid, aviation gasoline, rubber solvents as well as the commercial grades of natural gasoline for blending with other products in the manufacture of motor fuel.

Phillips Petroleum Company has two large batteries of fractionators; one at Lep Station, in the Burbank field, and another at Borger in the Texas Panhandle. Both of these plants are so arranged that any grade of natural gasoline can be turned out, but the one at Lep Station is operated in manufacturing "Philgas," the fighting grade of military aviation gasoline, and other close cut fractions. The Borger plant is not operated usually for any other purpose than that of reducing the current production of gasoline in that area to com-

mercial grades. Butane is produced, however, in a comparatively pure state for gas engine fuel and in the manufacture of high gravity anti-knock motor fuel.

In the operation of any of these batteries, whether in Oklahoma City, Seminole, Lep, Lyman, Marshall or Borger, the principal features are almost identical. If the current production of the fields, when reduced to natural gasoline in the raw state carries the following distillation characteristics, similar pressures and temperatures are utilized. For example, the grade of gasoline may be as follows:

91.6° .....A. P. I. Gravity.
Plus 30 .....Saybolt Chromometer
52° F. .....Initial Boiling Point.
100° F. .....40 percent over.
140° F. .....63 percent over.
212° F. .....78 percent over.
330° F. .....83 percent over.
330° F. .....End Point.
40 pounds .....Reid Vapor Pressure.

With this type of feed the column operation is about as follows (variations will occur caused by barometric pressure, atmospheric conditions, insulation efficiency, quality, quantity and temperature of cooling water): column pressures, 200 pounds gauge, kettle temperature 280° F. and the top section when the reflux is introduced is carried at 160° F. Of course, it is assumed that adequate exchanger equipment is supplied the battery, and those under discussion are provided with them. With the raw feed pumped directly from a battery of storage tanks so that the volume charged to the columns will not fluctuate to any great amount, the gasoline in process enters the column at any point (usually four are provided) where the temperature of the feed will correspond to the plate temperature in the column.

The finished product removed from the kettle, after passing through the exchangers and coolers, has the approximate following characteristics determined by A. S. T. M. distillation:

86.7°.....A. P. I. Gravity.
Plus 30.....Saybolt Chromometer.
62° F.....Initial Boiling Point.
100° F.....42 percent over.
140° F.....70 percent over.
212° F.....89 percent over.
340° F.....94 percent over.
340° F.....End Point.
26 pounds.....Reid Vapor Pressure.

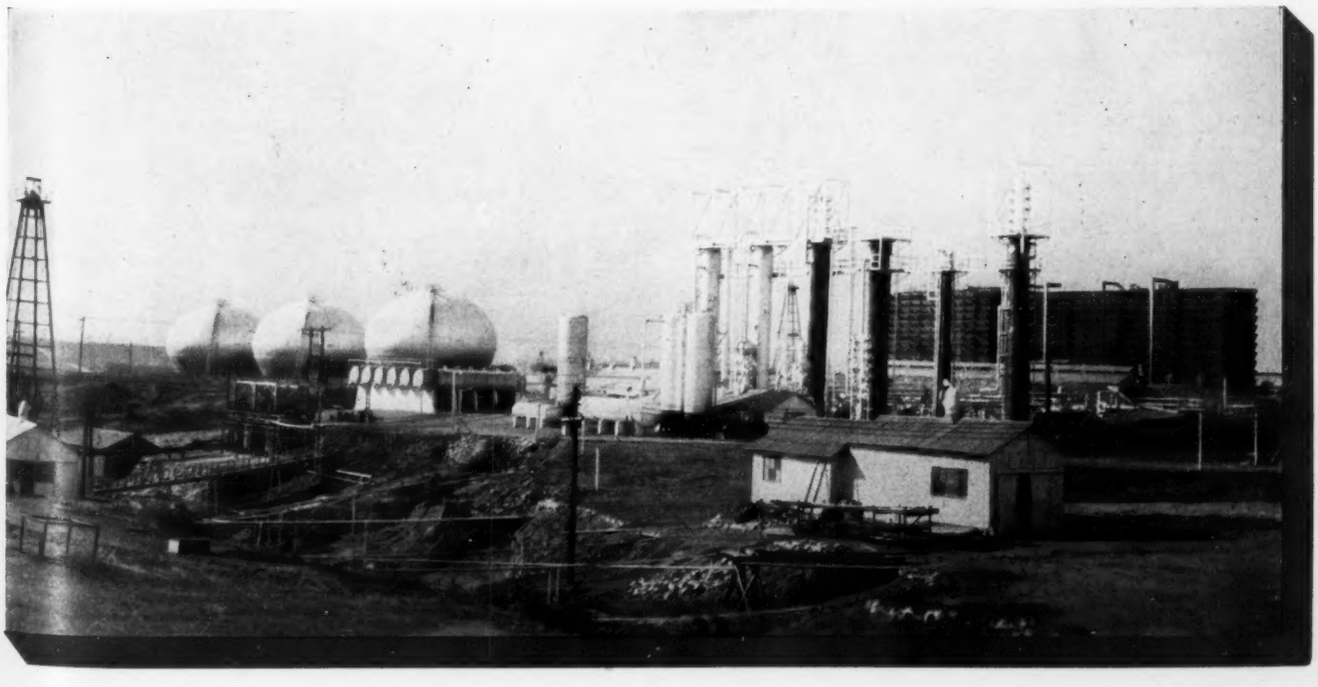
In the majority of instances where the stabilizers are operated on the above raw feed, producing a 26/70 finished gasoline, the reflux condensed in the shell and tube units have approximately the following characteristics:

Initial Boiling Point.....Minus 12° F.
End Point.....Plus 20° F.

If the vapors not liquefied in the reflux condensers are passed through supplemental condensers so that all of the overhead product can be saved, the following is the result of the blend of the two—reflux and final liquid:

Initial Boiling Point.....Minus 21° F.
End Point.....Plus 20° F.

To accomplish the results outlined above, it is only



Phillips Petroleum Company's central treating plant at Borger, Texas. Capacity 800,000 gallons of natural gasoline daily.

necessary to remove approximately 0.088 of the total feed to reduce a composite feed having a gravity of 91.6° A. P. I. and a recovery of only 83 percent, to one with a gravity of 86.7° A. P. I. and 94 percent recovery.

If the stabilizer, or battery of columns is operated in the manufacture of lower vapor pressure product, say for instance, 12-pound Reid, the tower or towers are carried as follows: column pressure, 140 pounds; kettle, or reboiler temperature, 290° F.; the top section 166° F. and the reflux around 150/160° F., depending upon liquefier efficiency. Assuming that the raw feed pumped to the columns when making a 12-pound product is comparable to that used when reducing to a 26/70, the results would be as follows:

80.3° F.....A. P. I. Gravity.
Plus 30.....Saybolt Chromometer.
92° F.....Initial Boiling Point.
100° F.....5 percent over.
140° F.....65 percent over.
212° F.....90 percent over.
340° F.....97.5 percent over.
12 pounds.....Reid Vapor Pressure

The rate of feed varies as to the product desired because of the larger amount taken off through the overhead vapor line when finishing to a lower vapor pressure gasoline. If the same rate is maintained when producing a low vapor pressure product as when cutting the raw to 26/70, the tower will be overloaded and will prime or pull over, and poor fractionation will result. The overhead stream, when the column is operated as above with a proper feed rate yields a condensate as follows:

Condensed liquid utilized as reflux:

Initial Boiling Point.....Plus 13° F.
End Point.....Plus 26° F.

If the reflux and the final liquefied product are blended, the following characteristics are found in the composite product:

Initial Boiling Point.....Plus 2° F.
End Point.....Plus 26° F.

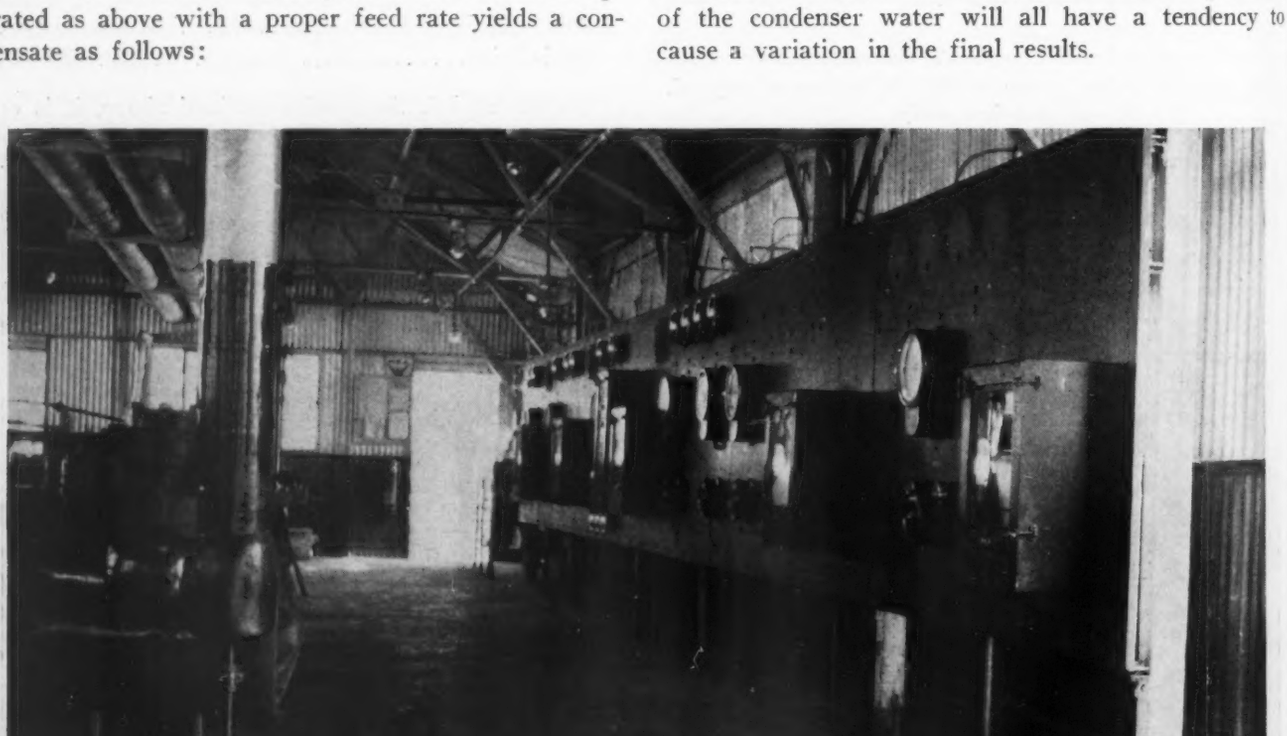
The amount removed from the raw gasoline as an overhead stream when processing a 91 gravity product to a 12-pound butane free gasoline will run approximately 25 percent.

When the accumulated overhead product is run for the separation of the two usual components—propane and butane—the column is operated under a pressure of 275 pounds gauge, the reboiler maintained at approximately 220° F. and the top section at approximately 135° F. Bottoms taken through the exchangers from the reboiler usually have the following characteristics:

Gravity.....113.8 A. P. I.
Initial Boiling Point.....Plus 16° F.
End Point.....Plus 26° F.
Vapor Pressure.....30 pounds gauge at 70° F.

About 70 percent of the feed charge to the column when processing the overhead from 12-pound gasoline will be recovered having the above characteristics.

All the above pressures and temperatures are approximate because the composition of the feed, the rate, atmospheric conditions, barometric pressure, altitude above sea-level and the condition and temperature of the condenser water will all have a tendency to cause a variation in the final results.



Control house, Phillips Petroleum Company's central treating plant at Borger Texas.

Recovery and Stabilization

Systems Combined at

Panhandle Plant

PANHANDLE Refining Company, Wichita Falls, Texas, recently placed in operation a modern pressure distillate debutanizing and vapor recovery plant. The principal features of this plant are the combination column built in two sections, one placed upon the other, and the fact that no recirculated absorption oil is used in stripping the vapors.

The two-section column is 30 inches in diameter by 64 feet in height. The top section is used as an absorber while the lower section takes the place of the conventional debutanizer. The absorption oil and the vapors are both handled in the upper section in about the same manner as in any other absorber, but the oil is not recirculated as when using mineral seal oil or other close cut material.

The cracking plant in which the pressure distillate is manufactured is a Dubbs unit and a side stream is taken from the polymer tower after the vapors have been treated in the Gray towers. This side stream is removed from above the third plate—counting from the top—to be used as material for absorption oil. As it is removed in the raw unfractionated state, this material has a gravity of about 50° A.P.I. and the amount required to operate the absorber averages about eight gallons per minute. It flows from the accumulating pan in the polymer tower under that column's process pressure to a stripper tower placed beside it where the lighter fractions are removed. The stripping column is equipped with a reboiler, heated with residuum from the cracking plant, and agitation of the material in the base of the column is accomplished by injecting a small stream of residue gas from the top of the combination column in the vapor recovery and debutanizing plant. This tower acts as a stabilizing column for the "heavy cut" by reducing the gravity of the stream processed in it from 50° A.P.I. to 47° A.P.I.

The amount of material removed from the polymer tower and fed to the stripping column is governed by the action of a control float set on the side of the tower, permitting more liquid to flow as the level is lowered, and shutting off the flow if the level rises. The fractionated heavy cut is removed from the base of the stripper with a 6 x 3½ x 6 steam-driven pump governed by an automatic controller which controls the amount of steam admitted to the pump through a valve at the throttle. The stabilized "heavy cut" is pumped

Combination pressure distillate debutanizer and vapor recovery unit in Panhandle Refining Company's refinery at Wichita Falls.

through atmospheric coolers before being admitted to the absorber section of the main column in the recovery plant.

The quantity of this heavy cut removed from the polymer tower and stabilized in the stripper column is determined from plant analysis of the residue gas and while conditions there remain constant, the volume is not changed. Adjusting the speed of the "heavy cut" charging pump by setting the controller so that more or less steam is admitted to the pump regulates its speed, and by so doing, the float control on the side of the stripper column automatically controls the amount of the material released from the polymer tower. Therefore during the normal operation of the recovery plant and the cracking unit the amount of the "heavy cut" is always under control. If the pump is shut down, the heavy cut will not be permitted to flow down from the plate and will be removed finally as vapor from the overhead line as it did before the polymer tower was tapped for the removal of this product. When operating the plant with these two instruments balanced it is not necessary to provide extra tankage to receive the heavy cut as there is a sufficient amount in the base of the stripper column to take care of normal plant fluctuation.

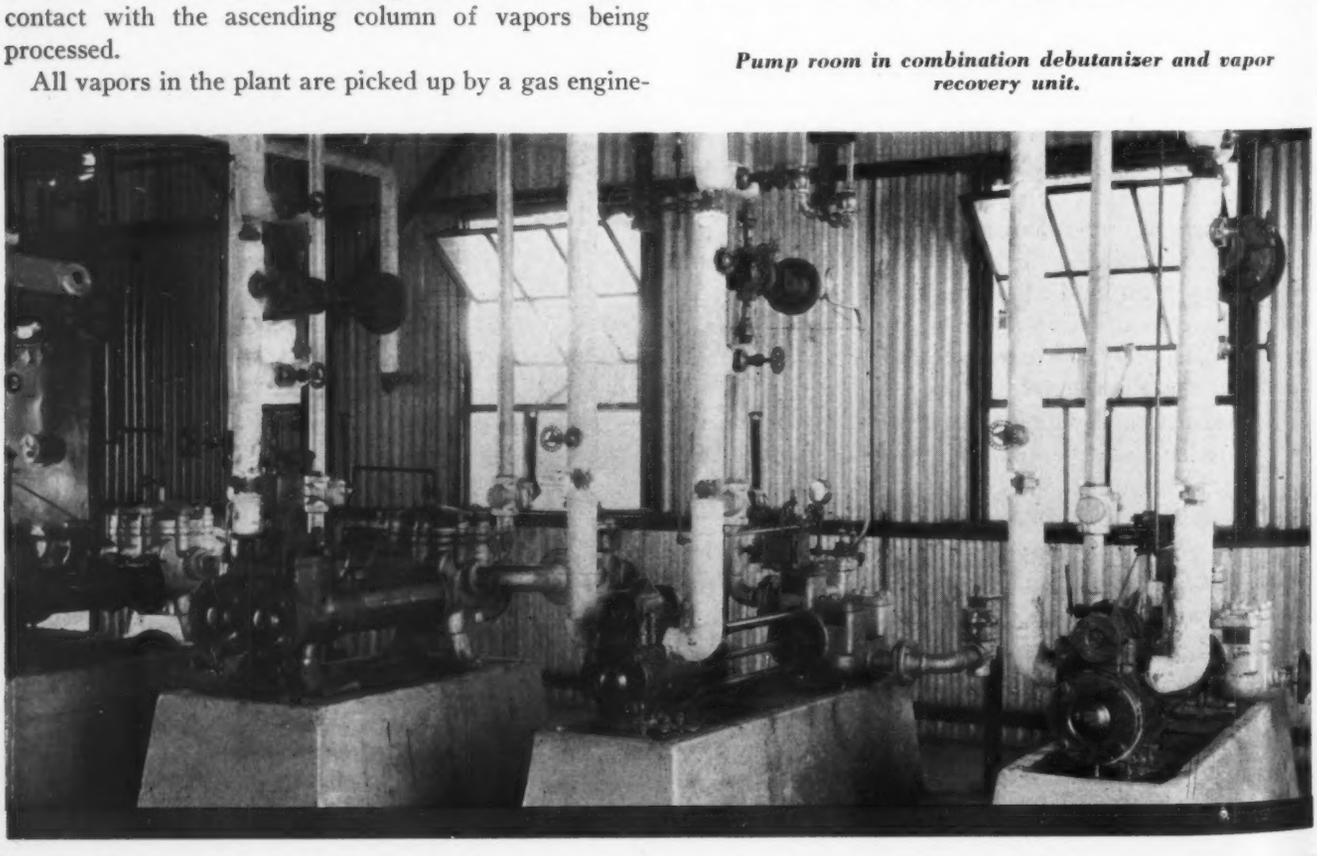
The pump handling the reduced heavy cut takes suction at 15 pounds (the operating pressure of the stripper column) and discharges at 150 pounds, (the pressure under which the main column is operated) to the top of the upper section of the combination column. This material, which now takes the place of an absorption oil, flows downward over the plates in the same manner as if the column were an ordinary absorber, coming in contact with the ascending column of vapors being processed.

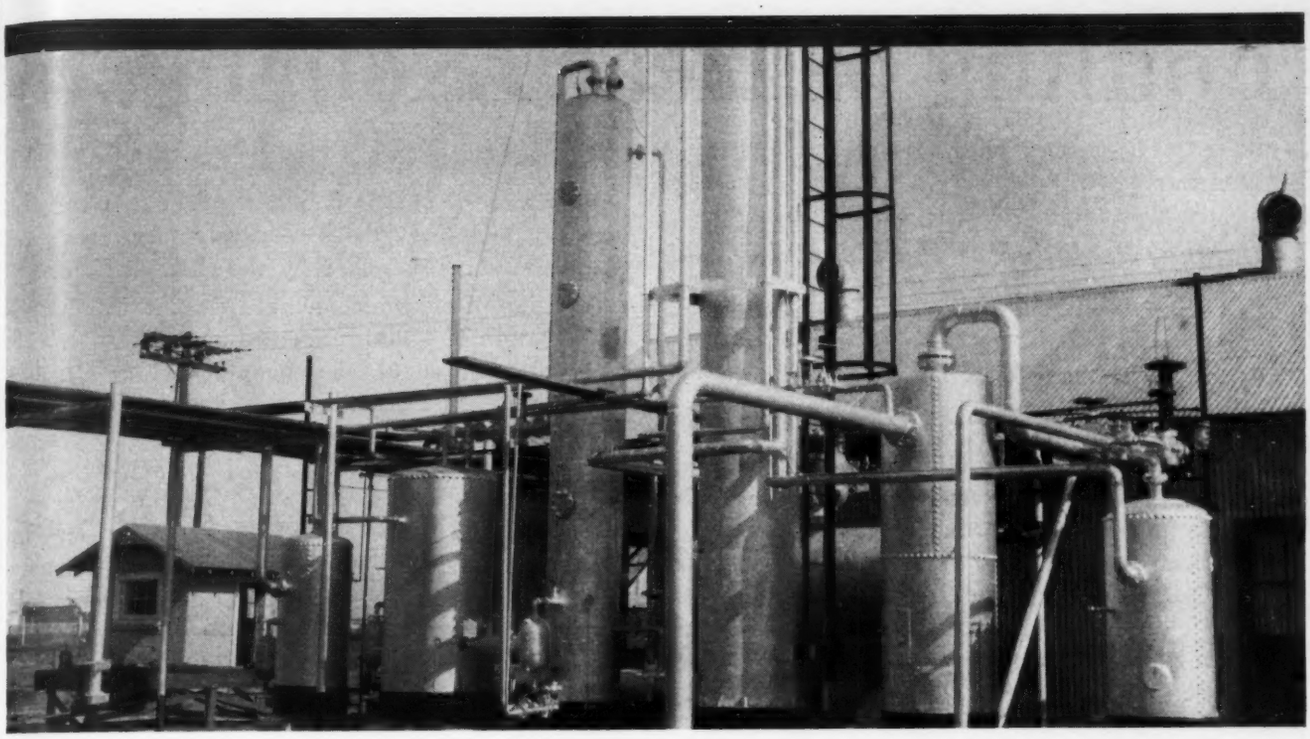
All vapors in the plant are picked up by a gas engine-driven tandem compressor which receives them from the pressure distilalte receiving drums, plant storage tanks, the top of the "heavy cut" stripping column and from the top of the flash column reflux accumulator drum. These are all handled through a scrubber to remove possible condensation and are taken into the low pressure cylinder of the engine. The low cylinder discharges directly to the inter-coolers placed as atmospheric sections in the louvre tower and returns to the intake of the high cylinder through an accumulator tank in which all condensate is removed from the gas before it enters compressor.

This cylinder compresses the entire charge of vapors to 150 pounds. The compressed vapors then pass through another bank of atmospheric sections before they enter the base of the top section of the main column. Separation of the desirable fractions from the vapors is accomplished in the top section by absorption as in conventional columns and the residue passes out through the top. A small scrubber is placed in the line of flow to remove any liquid that might be removed from the column by the stream of stripped vapors. After passing through this tank, the gas is introduced into the plant fuel lines to be consumed in the furnaces supplementing the regular fuel supply.

The condensed pressure distillate is picked up by a 6 x 3½ x 6 steam pump, set beside the "heavy cut" pump, and discharged at 150 pounds through a preheater to enter the bottom section of the main column at a point near the top. The rich oil from the upper section, having absorbed the desired fractions from the vapors, also enters the top of the bottom section. It is transferred through a plate separating the two sections

Pump room in combination debutanizer and vapor recovery unit.





Details of accumulator and scrubber arrangement around main flash columns.

by a down spout sealed with a weir plate so that nothing can pass from one section to another except the descending rich "heavy cut." The two classes of material being processed are blended in the top of the bottom section, passing downward over the stabilizing stripper plates to the base. A reboiler set near this column is heated with steam from the boiler battery to 320° F. instead of residuum because of the fact that the heat from the residuum is used at other points in the refinery.

Vapors driven from the pressure distillate and saturated "heavy cut" pass upward through the column, and when released at the top of the bottom section, termed the "mid-section," they are directed through a water cooled reflux condenser set on brackets attached to the tower at the "mid-section." The temperature of this condenser is controlled by varying amounts of water passing through the shell and tube unit. Water flowing through this unit is automatically controlled and the temperature maintained at this point is determined from the vapor pressure desired on the stabilized product. During the present operation the temperature is maintained at 140° F. and the condensate coming from the shell and tube condenser flows back to the top plate of the bottom section as reflux. Uncondensed vapors passing through this mid-section cooler are released to the bottom of the top section of the column to come in contact with the descending "heavy cut" for reabsorption and absorber fractionation.

A flash column set beside the main column receives the hot bottoms through a liquid level controller which reduces the pressure from 150 pounds to 92 pounds and the reduction of pressure also reduces the temperature from 320 to about 225° F. Overhead vapors removed from the flash column are led through a bank of atmospheric condensers and returned to the drum next to the column. A duplex steam pump, 5½ x 3 x 7 picks up this liquefied product and discharges it through two valves, one of which operates as a back pressure regulator on the discharge, while the other is automatically controlled and determines the amount of condensate necessary for reflux to the top of the flash column. The back pressure regulating valve permits that part not necessary for reflux to be pumped to storage. Through this hook-up of a half-inch valve, operated by the controller, and a half-inch back pressure valve on the line to the storage tanks, it is not necessary to install and operate two pumps—one for reflux and one for pumping to storage—and the one pump performs both duties. The gasoline recovered in the flash drum accumulator averages around 87.5° A.P.I. About 4500 gallons per day is recovered from the refinery vapors in this manner, the amount almost meeting the requirements of the plant for natural gasoline.

Another duplex pump, 5½ x 3 x 7, is used in handling the condensate from the high compression vapors and this material is picked up from the accumulator tank and pumped back to the top of the bottom section of the main column for fractionation. A float control on the side of the accumulator controls the speed of the pump through a remote control valve on the steam line leading to the steam chest of the pump.

The bottoms of the "flash tower" being stabilized pressure distillate, pretreated in the vapor phase through the clay towers, is discharged through a liquid level control to a bank of coolers to temporary storage before it is finally chemically treated.

Fouling of Heat Exchangers

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PART II

LACK of data regarding fouling has been partly due to the confusion concerning a basis for study. Doubtless much plant information has been recorded but no clear-cut method of correlating the data has been presented. In computing fouling factors two types of clean transfer rates have been used. The clean rate may be determined on the exchanger after it has been cleaned or the clean rate may be computed by means of the theoretical formulations of film transfer rates. The latter method gives much higher fouling factors.

Use of the transfer rate of the clean exchanger as a basis, has many advantages. In an isolated plant the superintendent can take temperatures on exchangers, etc., and by using the rate when the exchanger is clean as a basis, fouling factors can be tabulated. Consistent factors can be obtained in this manner and the method involves no elaborate knowledge of heat transfer nor does it involve complicated calculations. This method was followed in obtaining the fouling factors given in Table II in the article published in July.[1]

However, if fouling factor data are to be accumulated from many plants, the above method is not entirely satisfactory. The cleaning will be accomplished more thoroughly in some plants than in others and the data will not be consistent. For this reason I have chosen to compute fouling factors by the use of the more general basis, that is the use of theoretical film transfer rates. No great progress can be made in the correlating of fouling data until some common basis is adopted by all investigators. At the present time it is difficult to ascertain just what basis was used in computing the factors that are reported in the literature. However, the use of film transfer rates as a basis has not been possible until recently because film transfer rates for all conditions were not available. Film transfer rates are now available and although they may not be exact, they are not inaccurate enough to cause large errors in the computed fouling factors. An error of over 10 percent can be tolerated in most film transfer rate data without greatly affecting the accuracy of the fouling factor. This is due to the fact that the fouling resistance is usually relatively large compared to the resistances caused by the films of fluid.

Another phase which should receive attention is the isolation of fouling factors for each surface. The fouling factor should be made up of two factors. One for one side of the surface and another for the other side. As an example a fouling factor for a tubular cooler may consist of two items—a factor of 4 on the oil side and a factor of 8 on the water side, making a total factor of 12. No amount of cleaning on the water side alone, can decrease the total factor to less than 4 even through the fouling on the water side is far worse than on the oil side. At the present time little can be done about isolating the factors for each surface because so few data are available.

The disadvantage of the use of film rates as a basis for computing fouling factors is the complexity of the calculations. It is necessary to have complete data on the exchanger. The velocities on both sides of the exchanger must be known, the number of passes on each side must be known, the properties of the two fluids must be determined and great care must be used at every step in the calculation to see that some apparently small detail does not inject a large error. Even the determination of the film rates may involve elaborate computations. Nevertheless, no other universally useful method of designing exchangers or applying fouling factors appears to be tenable.

Another question of basis is the use of percentage factors of safety versus the use of resistance factors. This controversy has been settled by all skillful engineers in favor of the use of the resistance concept as outlined in these articles. An illustration clearly shows why the use of percentage factors has been abandoned. Consider an exchanger condition in which the scale is equivalent to a resistance of 0.005 (factor of 5). At a low velocity the overall film rate is 50 and at a high velocity the overall rate is 150. By a percentage factor of 20 percent the rates are dropped to 40 and 120 respectively. But by the use of the resistance (0.005) the rates are 40 and 94. Thus the use of a safety factor of 20 percent was altogether inadequate for the high velocity operation although it was satisfactory enough for the low velocity.

FILM TRANSFER RATES

As mentioned above, the fouling rates in this paper are based on clean overall rates of heat transfer which were computed by means of the film coeffi-

[1] "Introduction to the Fouling of Heat Exchangers" Refiner pg. 271, July, (1934).

cients. Space does not permit a complete discussion of film transfer rates but it is necessary to give the equations[2] by which they can be computed.

Water Inside Tubes—

For turbulent flow in clean pipe the Frost[3] equation is generally used:

$$h_w = \frac{14.5k}{D}\left(\frac{D_v}{Z}\right)^{0.8}\left(1+\frac{50}{r}\right)$$

Water outside of tubes and in natural convection—

Little data are available. The following rates were used:

Velocity	Transfer Rate (outside)	Condition
..	150	Lab. equipment (small) pipe coils
..	110	Lab. equipment (small) ribbed sections.
0.5	170	Slow natural convection (commercial).
1.0	200	Natural convection (commercial)
2.0	280	Forced circulation
4.0	390	Forced circulation
6.0	460	Forced circulation

Oil Inside Tubes—

The data of Whitman & Morris[4] were used. These data are presented in the form of a convenient chart. The equation of Sherwood and Petrie[5] for all fluids including gases, may also be used.

$$\frac{hd}{k} = 0.024\left(\frac{d^2 U^2 p^2 c}{\mu k}\right)^{0.4}$$

The viscosity μ is given in English units. Multiply Z by 2.42.

Oil Outside Tubes—

The only formulation is for sugar and molasses solutions. The author has determined the following approximate rates from commercial oil equipment:

Transfer Rates at the following Viscosities (Centipoises)

Velocity	10	3	1	0.5
0.5	17	24	33	56
1.0	30	44	70	90
2.0	48	70	115	160
3.0	60	98	165	260
4.0	74	130	260	470

Oil Vapors Condensing—

The equation of Kirkbride[6] (Merkel) was used—

$$h = 0.725\left(\frac{k^3 p^2 \lambda g}{\Delta T d \mu n}\right)^{0.25}$$

Steam Condensing—

The rates for condensing steam are so high that they are not of great importance. A value of 1500 was used.

Cooling Vapors Outside Tubes—

Little data for petroleum are available but the rates by the equation of Monrad[7], reduced by a small amount, were used:

$$h_g = \frac{1.75\ V^{.667}\ T^{.3}}{D^{.33}}$$

In computing the overall coefficient for commercial equipment great care must be used. The film coefficients must be carefully determined, corrections of the mean temperature difference for the number of passes in the shell and tubes must be made and in some cases the logarithmetic mean temperature difference is not exact and integration methods must be used in determining the true mean temperature difference.

COMMERCIAL FOULING FACTORS

The magnitude of commercial factors can be best approached by means of a chart. Figure 1 shows factors that were obtained in commercial equipment. The lines in the figure are merely boundaries of the several conditions of fouling. It would be more convenient to draw average curves for each condition but to draw such a definite relation would be misleading. The desire of every engineer is to have definite fouling factors so that the responsibility can thus be lifted from his shoulders. This would be a restful solution to this troublesome problem but such a solution will probably never be possible. Each condition of fouling is a new condition and can only

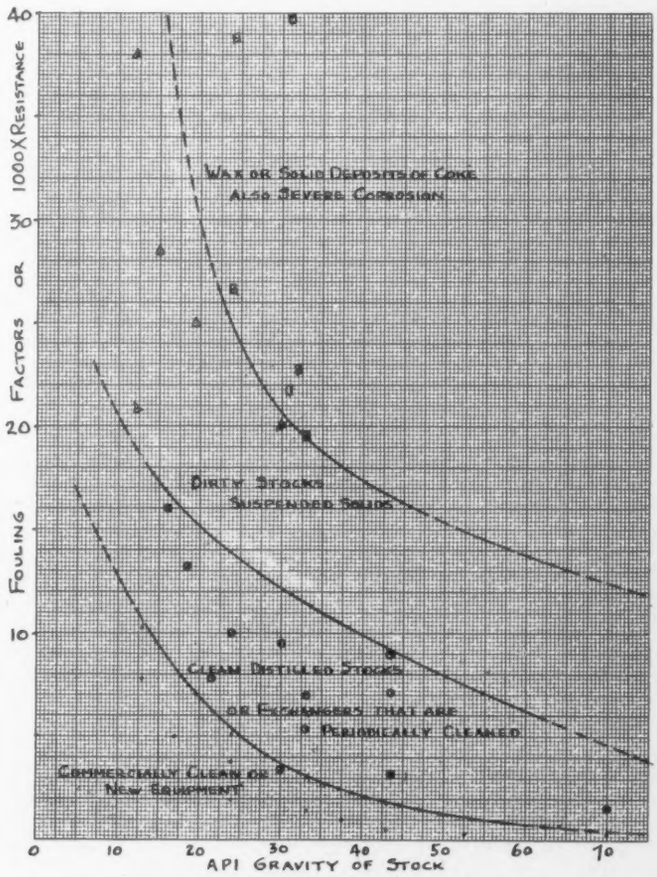


FIGURE 1

Fouling Factors on the basis that the transfer rate by the film coefficients has a zero factor. (Tubular equipment).

[2]The author has plotted these equations as charts as a facility in calculating.

[3]McAdams & Frost-Refrigerating Engineering 10 No. 9, Mar. (1924).

[4]Ind. Eng. Chem. March, (1928).

[5]"Heat Transmission to Liquids Flowing in Pipes." Ind. Eng. Chem. 24:737 (1932).

[6]" . . . Condensing Pure and Mixed Substances . . . " Ind. Eng. Chem. 25:1324 (1933).

[7]Ind. Eng. Chem. 24:505 (1932).

be met by the judgment of the designer. Under these conditions, we have really been remarkably successful in designing heat exchangers.

The factors which most actively affect the fouling factor are (1) the amount of dirt in the stock, (2) the presence of wax, (3) the gravity of the stock and (4) the velocity. The effect of gravity is indicated in Figure 1. No reason is apparent for the high factors found with clean low gravity oils. However, these oils, even though they are clean, deposit

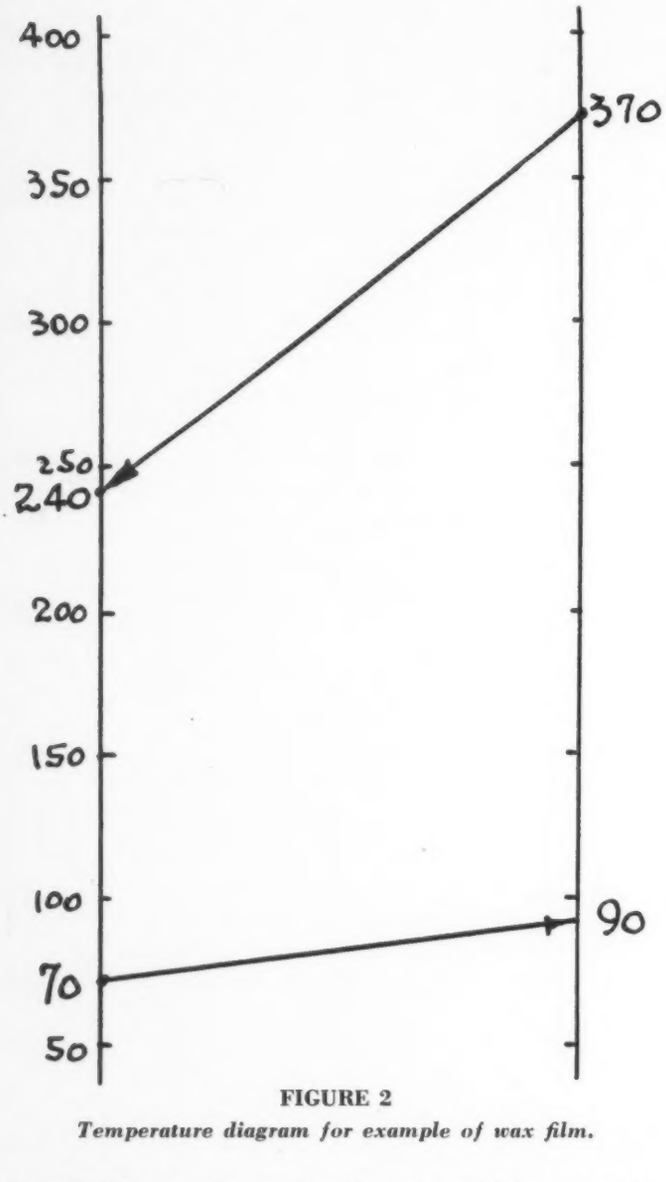


FIGURE 2

Temperature diagram for example of wax film.

varnish-like or grease-like deposits which are probably produced during heating.

Velocity accounts in part for the range of factors that is found for each condition. No direct relationship is possible because of the wide difference in the tightness of the scales. Velocity is very effective in reducing the factor if the deposit is loose but for certain hard scales it has little effect.

The fouling factor may be estimated in the following manner:

An exchanger is to cool wax distillate (480-280°F.) in the tubes (3.7 ft/sec.) by means of crude oil (160-230°F.) at velocity of 1.8 feet per second. The stock is clean and the exchanger will be blown with steam each week. The factor (Figure 1) may range from about 3 to about 12. However, these conditions are favorable and a factor of 5 may be expected. If the exchanger were not blown with steam the factor would be nearer 9. If the temperature were lower, as in a cooler, a wax film would be produced and a factor of 25 or higher should be expected. The factors in Figure 1 are for both surfaces together.

The fouling factors that are found in the literature are usually lower than shown herein. Most of these were computed by using the transfer rate of the exchanger after it was cleaned, as the basis. The factors shown in Figure 1 would need to be reduced by 0.5 to 10 to place them on a comparable basis. (Note the area in Figure 1 for commercially clean equipment). Many of the factors given in the literature were obtained in equipment that was periodically cleaned. The authors have not always been careful in stating the exact condition under which the factors were determined.

WAX DEPOSITS

The resistance of wax deposits does not appear to be due to wax alone. The wax probably picks up particles of dirt and incorporates it into the film. The exact temperature at which a deposit of wax will begin to form can only be estimated. If any part of the oil film is at a temperature below the freezing point of wax a deposit will be produced. Most commercial wax, even though the average melting point is 120°F. contains wax which melts at 160°F. and a lower temperature than this, in the film, will cause wax scale. The following example based on commercial operating data will indicate the nature of wax scale formation.

A wax distillate cooler was operating as follows:

Shell side-wax distillate

Velocity.....1.1 ft./sec.
Inlet.....370°F.
Outlet.....240°F.

Tube side-water

Velocity.....2.1 ft./sec.
Inlet.....70°F.
Outlet.....90°F.

The temperature diagram is shown in Figure 2. Actual transfer rate 23.

The transfer rate by film coefficients is:

$$H = \frac{1}{\frac{1}{51} + \frac{1}{450}} = \frac{1}{.0195 + .0022} = \frac{1}{.0217} = 46.1$$

The temperature difference through the oil film before any wax is deposited is:

$$\frac{.0195}{.0217} \times (240-70) = 153^\circ \text{ (low end)}$$

also

$$\frac{.0195}{.0217} \times (370-90) = 252^\circ \text{ (high end)}$$

The lowest temperatures in the film are:

240—153 =87°F. and 370—252 = 118°F.

The percentage of oil film below the freezing point of wax (160) is:

$$\frac{160-87}{126} \times 100 = 58.0 \text{ percent}$$

$$\frac{160-118}{252} \times 100 = 16.7 \text{ percent}$$

Average 37.4 percent

The conductivity of mushy wax is almost the same as oil. Hence the wax scale that is first produced will have a resistance of $0.0195 \times .374 = .0073$. But even after this wax is deposited a part of the new oil film will be at a temperature lower than 160°F. and even more wax will be deposited. Thus the temperature drop through the oil film after some wax is deposited is:

$$\frac{.0195}{.0217 + .0073} (240-70) = 114^\circ \text{ temperature diff.}$$

Low temperature in film = 240—114 = 126°F. At the hot end of the exchanger the low temperature in the film is 183°F. and no more wax is deposited.

By continuing the problem in this manner the final resistance of the wax scale becomes:

1	.0073
2	.0027
3	.0010
4	.0003
5	.0001
Approximate total resistance	.0114
Fouling Factor (by wax)	11.4

The actual fouling factor was 19.5 so that part of the fouling must have been due to other factors than the influence of wax. Possibly it is due to the accumulation of dirt, etc., in the wax film.

This example, though it is not altogether a satisfactory explanation of wax scaling, does illustrate the importance of the temperature in the film. It is apparent that any method by which the temperature in the wax distillate film can be increased will aid the fouling condition. This can be partly accomplished by increasing the velocity on the oil side and perhaps to lower the velocity on the water side would be beneficial.

WATER SCALE

The formation of water scale also illustrates the effect of the film temperature. The solubility of gypsum in water increases to a maximum at about 100°F. At higher temperatures the solubility decreases rapidly so that over 20 percent of the gypsum will be deposited if the saturate solution is heated to 212°F. Thus the solubility decreases with temperature (above 100°F.) and the scale is deposited in the film at the surface (as in the case of wax) because the temperature in the film is higher than in the main body of fluid. The scale continues to build up until the temperature of the water film is depressed by the resistance of the scale until it is sufficiently low to retain the sulfate in solution. Calcium carbonate behaves in much the same manner except that it is more soluble and hence does not give the trouble that is experienced with sulfate scale.

The temperature of the cooling water is usually held to a maximum of 125°F. Thus little sulfate is precipitated in the bulk of the water but the temperature in the film will always exceed 125°F. at, at least, one end of the exchanger.

COKE DEPOSITS IN PIPE STILL TUBES

Solid coke is also deposited on heating surfaces because of the high temperature in the oil film. However, the problem is usually different than with wax or water scales because the tube or surface is heated by radiation. The amount of heat that is transferred is not decreased greatly by the presence of a scale but the temperature in the metal wall rises as this scale accumulates.

Radiant heat is generated at a constant rate in a boiler or pipe still and is not dependent to any large extent on the condition past the heating surface. The radiation falls upon the tube and as long as this amount of radiation is available the tube will absorb it irrespective of the coke deposite on the inside. This is true until such a time as the wall temperature approaches the furnace temperature. If the tube wall reaches the furnace temperature the operation must stop and hence the condition is not of practical importance. The fact that the heat absorption remains nearly the same in spite of thick deposits of boiler scale has been experimentally studied by Partridge and White[8] and others. They find that heat absorption is usually not reduced by more than three percent by normal boiler scale. The same amount of scale might cause a decrease in heat absorption of 100 percent in a heat exchanger because heat is not transferred by radiation in a heat exchanger.

As the wall temperature rises the coke temperature also rises and it is cooked into a hard dense deposit. The mechanism of this phenomenon can be most easily explained by an example:

A steel pipe still tube receives radiation at the rate of 5500 Btu per square foot per hour of outside surface or a rate of about 9500 Btu per square foot of inside surface. The velocity of the oil is such that the film transfer rate is 200 Btu per square foot per hour per degree of temperature difference. Obviously the temperature difference through the oil film, if the tube is clean, is:

$$\frac{9500}{200} = \frac{\dfrac{\text{Btu}}{H_r \times F_t^2}}{\dfrac{\text{Btu}}{H_r \times F_t^2 \times {}^\circ\text{F.}}} = 47.5^\circ\text{F.}$$

If the oil temperature is 900 degrees the tempera-

[8] "The Effect of Boiler Scale" Ind. Eng. Chem. 21:839 (1929).

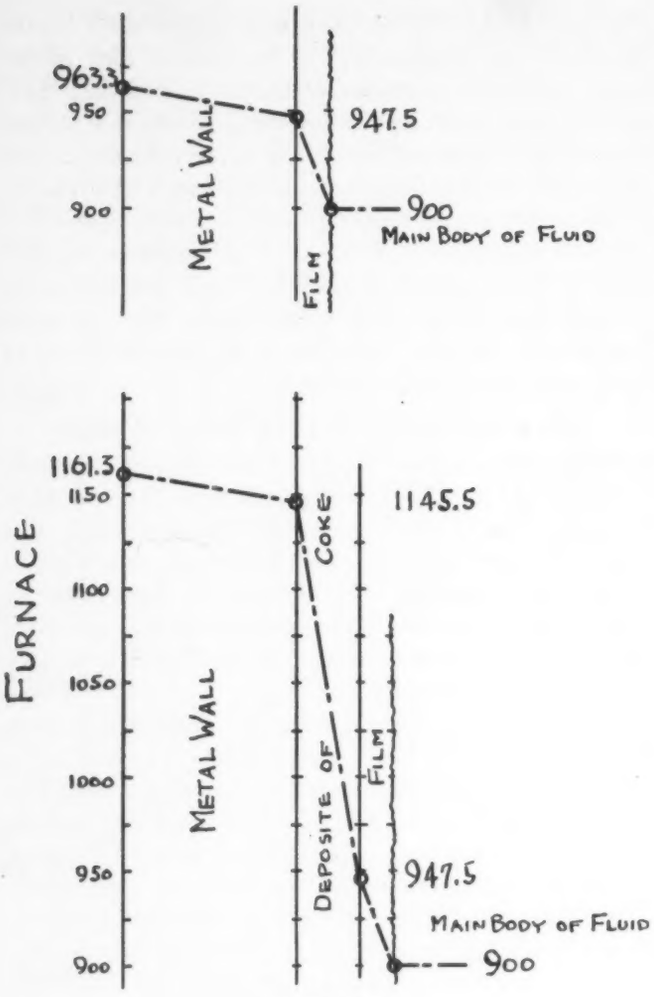


FIGURE 3

Temperatures in pipe still tube.

ture at the inside of the wall is (900+47.5) or 947.5° F. If the wall is one half-inch thick the temperature drop in the wall will be

Conductivity of Steel = about 25 Btu per deg. F. (diff.) per hr. per sq. ft, per ft. of thickness

$$\text{Deg. drop in wall} = \frac{9500}{25} \times \frac{.5}{12} = 15.8$$

and the outside of the metal tube is at $900 + 7.5 + 15.8$ or 963.3 deg.

If a coke deposit (conductivity about 0.5) one eighth-inch thick is produced, the tube temperature is increased by

Increase in wall temperature due to coke.

$$\frac{9500}{0.5} \times \frac{.125}{12} = 198°\text{F.}$$

and the outside tube temperature is

$$900 + 47.5 + 198 + 15.8 = 1161.3°\text{F.}$$

A temperature of 1160° (red heat) is too high for a carbon steel tube because the strength drops to less than 1000 pounds per square inch (for a long period of time) and the tube will fail. However, if the pressure is very low so that the coke can be deposited to thicknesses greater than one eighth-inch the tube wall temperature continues to rise with increase in coke thickness and eventually the tube will attain the temperature of the furnace. At this stage the furnace must be fired harder; the temperature in the tube rapidly mounts; the pressure drop increases rapidly and eventually the tubes become plugged or they fail. The temperatures that were computed in the example are shown in Figure 3.

As the coke is deposited the temperature in the coke itself steadily increases so that it becomes more dense and hard as time progresses. The rate at which the coke is deposited is not greatly affected by the thickness of the coke deposit. Accumulation takes place at a rate about proportional to time. The temperature in the oil film remains about the same and hence the amount of cracking in the film proceeds at about a constant rate.

The rate of coke deposition is not dependent on the amount of coke already deposited but it can be retarded by increasing the velocity or the transfer rate through the oil film. The rate of depositing coke is vitally dependent on the thickness of the oil film because the thicker the film the greater the volume of oil (in the film) that is exposed to the high temperature. Thus the rate of coke deposition will be related to the transfer rate and the temperature in the film. Figure 4 shows the relative rate of coking for different film transfer rates and for common rates of total heat absorption. They are based on a rate of unity for a transfer rate of 300 and an absorption rate of 10,000. These conditions are commonly found in cracking plants. The data are only approximate because the velocity and the film transfer rate cannot be accurately computed. Two factors were accounted for in computing Figure 4: one, the temperature in the film and the way that it affects the rate of cracking and the other, the thickness of the film.

The curves in Figure 4 clearly show why a hot velocity of about 13 feet per second is now commonly used in cracking plants. A higher velocity greatly increases the pressure drop and aids little in decreasing the formation of coke. Absorption rates of 10,000-13,000 (through the inside surface of the tube) are widely used. In topping plants the temperature in the main body of oil is much lower and hence Figure 4 does not apply. A similar diagram for topping pipe stills would cover a transfer rate range of 150 to 250 and absorption rates from 15,000 to 30,000.

MATERIALS FOR PIPE STILL TUBES

The above discussion of coke deposits raises the question of the material to be used in pipe still tubes. It appears that no material can be expected to withstand thick deposits of coke. Nevertheless, some materials can be heated to higher temperatures than

others and hence a thicker coke deposit can be tolerated.

Tubes for cracking stills (2″ I.D.) usually have walls that are 0.5 inch thick. Such a tube if used at a pressure of 1000 pounds per square inch must have a strength of about 3000 pounds per square inch at the temperature that the tube will attain in service. Regular mild carbon steel (0.2 percent C) has a creep-strength (1 percent in about 14 months) of 3000 pounds at about 1030°F. In heating an oil at 900°F. the thickness of the coke deposit could be

Total Temperature drop (1030—900) = 130°F.
Drop through film approx. 33°F.
Drop through tube approx. 16°F.

$$\frac{49}{} \qquad \frac{49}{}$$

Drop through coke scale.....81°F.

Absorption rate 10,000 Btu per hour based on inside surface.

$$\text{Thickness of coke inches} \frac{kA\Delta T}{Q} \times 12 = \frac{.5 \times 81 \times 12}{10{,}000} = .0485$$

This corresponds to a thickness of about 3/64 of an inch. It is not to be inferred that the tube will fail immediately after a deposit of 3/64 inch is produced. The material will stand this condition for a short time but it will begin to soften and failure occurs shortly. No real gain in the length of operating time is possible by using the tube in this condition and the danger of fire increases.

TABLE 1

MATERIAL	Temp. for a Creep Strength of 3000 lbs. (1% in 10,000) An Oil Pressure of 1000 lbs.	Temp. Drop Through Coke Deg. F.	Allowable Thickness of Coke Deposit Inches	Relative Length of Service Before Cleaning
Carbon Steel.....	1030	81	.0485	1
4-6 Chromium.....	1060	111	.0666	1.38
0.5 Molybdenum steel	1110	161	.0965	2.0
4-6 Chrom 0.5 Mo...	1150	201	.1205	2.5
18-8 Chrome Nickel..	1400	451	.271*	5.6*
Calite B.....	1620	671	.403*	8.3*

*True unless the pump pressure becomes prohibitive.

Many alloy steels retain their strength at an elevated temperature and hence they are being widely used as tube materials. Several of these alloys were studied as in the above example to determine the relative thickness of coke deposit that can be tolerated with each of the alloys. The coke is deposited at a rate nearly proportional to time and hence the coke thickness (barring plugging of the tube or the production of an excessive pressure drop) that can be allowed is a measure of the time that the tube

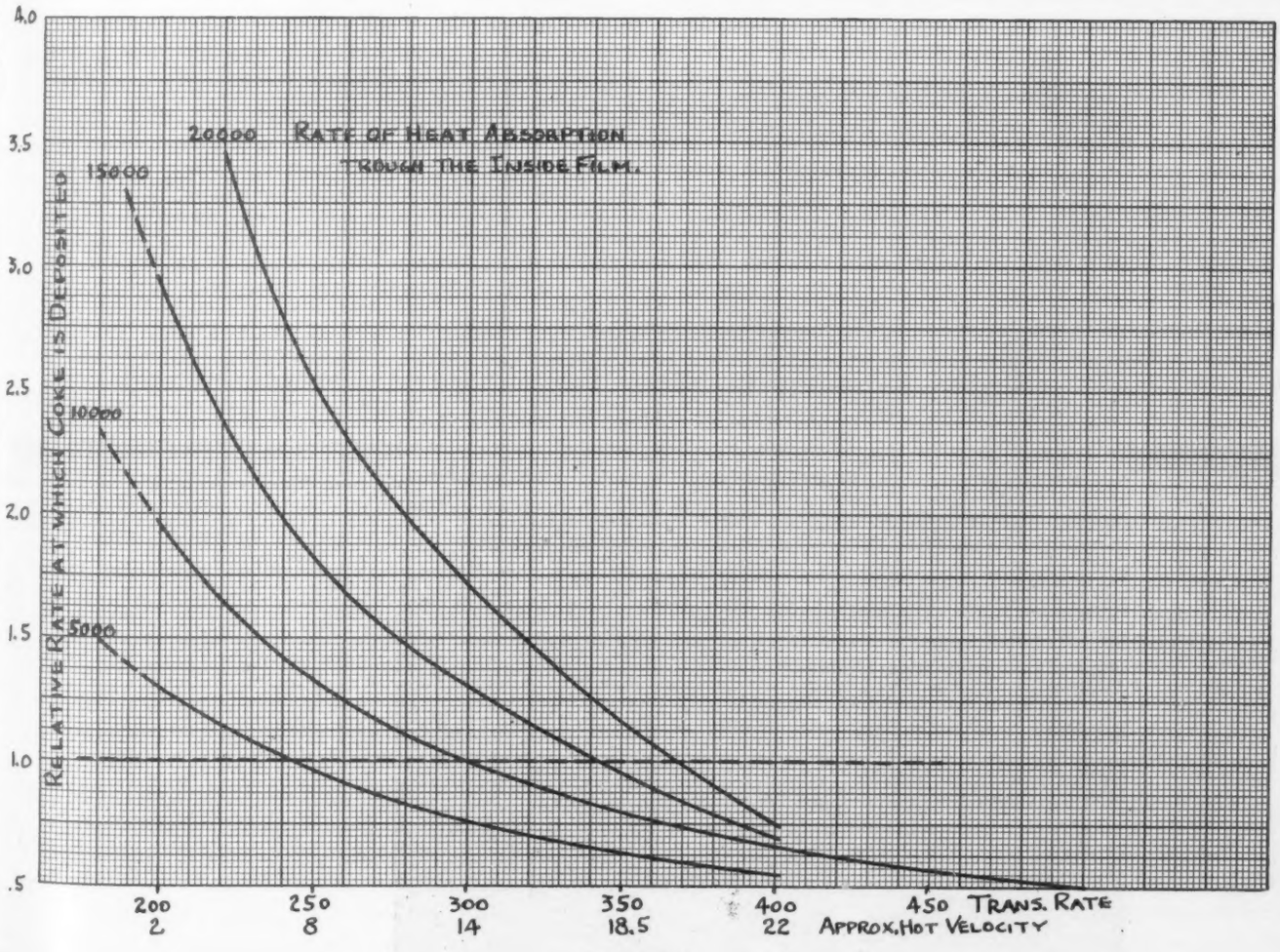


FIGURE 4
Rate of coke formation in pipe still stubes.

can be used before it must be cleaned. Table I presents this information.

The last two materials in Table I cannot be cleaned as infrequently as shown in the table because the pump pressure will increase. Furthermore, the furnace temperature, near the tube, seldom exceeds 1400°F. and hence the thick deposits indicated in the table would necessitate that the furnace be fired harder. It would appear that 0.5 molybdenum tubes would be an advantage and at the same time would insure additional safety in operation. Most of these alloy steels are resistant to corrosion and high temperature oxidation but this is a usefulness that is not intimately related to fouling by coke.

At lower pressures the deposits of coke could be thicker before failure occurs but not greatly so because a few degrees of temperature changes the creep-strength greatly.

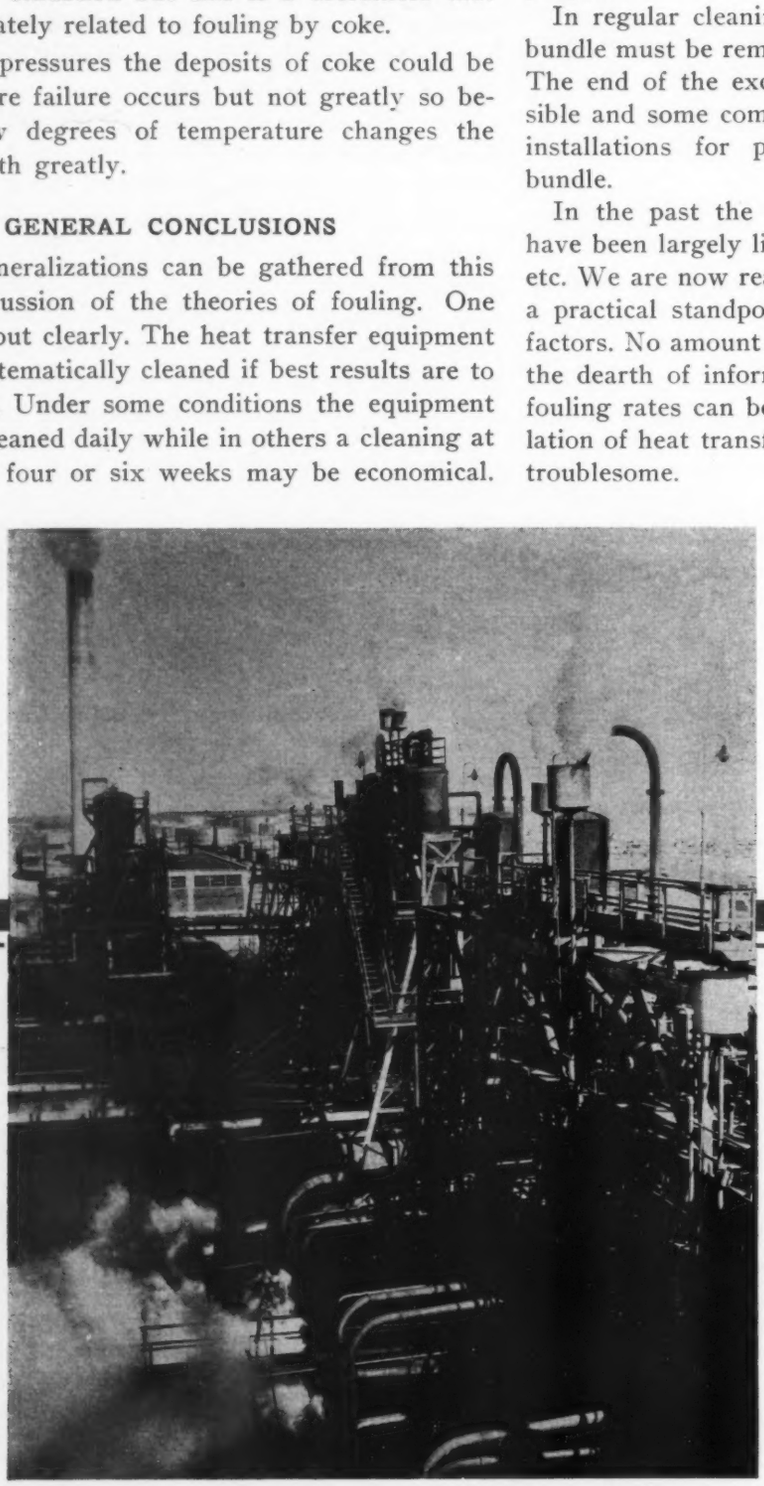
GENERAL CONCLUSIONS

A few generalizations can be gathered from this general discussion of the theories of fouling. One fact stands out clearly. The heat transfer equipment must be systematically cleaned if best results are to be obtained. Under some conditions the equipment should be cleaned daily while in others a cleaning at intervals of four or six weeks may be economical. Plant experience with the particular conditions can be the only guide in this matter.

With soft or loose deposits, blowing daily with steam or flushing with water may be sufficient but this method may be useless in combating hard scales. The exchangers can be connected so that they can be by-passed, drained and blown with steam, all in a few minutes without greatly disturbing the operation. The use of several small exchangers rather than a single large exchanger is one manner of facilitating cleaning and repairs. One large company has adopted the use of small units of exchanger, for all purposes.

In regular cleaning operations in which the tube bundle must be removed, special care must be taken. The end of the exchanger should be readily accessible and some companies have provided permanent installations for pulling and handling the tube bundle.

In the past the investigations of heat exchange have been largely limited to the study of fluid films, etc. We are now ready to work at the problem from a practical standpoint by the cataloging of fouling factors. No amount of theoretical work can atone for the dearth of information concerning fouling. Until fouling rates can be accurately estimated the installation of heat transfer equipment will continue to be troublesome.



Hydro-Metallurgical Methods

Applicable to Oil Refining

L. C. TRESCOTT

PART I

THERE are many problems of hydro-metallurgical work which are similar to the problems of the petroleum industry. This being the case it is highly probable that the methods of handling those problems, and the types of equipment of the mine mill, the leaching, and cyanide plants can be suitably modified and put to profitable use in the refining industry.

For years the continuous process has of necessity been a part of metallurgical work. The coming of such processes to the oil industry gives many additional points where the experience of the mining engineer can be applied. Of all the points common to both industries, none is more important than the matter of settling.

Leading the settling problems of the refinery comes the neutralization and washing of acid treated oils. Into this discussion the breaking of emulsions will not be brought. The conditions considered are those of normal plant operation where the soaps are broken out and if given sufficient time will settle, leaving a more or less clean oil. There is a distinct advantage in getting the soaps out on the first wash. Often the lighter soaps left after the primary washing will go into an emulsion when the original steaming up has broken clear. After all the washing of a neutralized oil is more a matter of settlement than just a matter of solution of the soaps in water and a study of the settling conditions in the washing process should result in a better quality oil and a material saving in time and trouble.

The washing of lubricating oils is almost without exception done by batch methods. As a rule the neutralized batch is steamed through with live steam, then kept as quiet as possible until, if the gods so will, the soaps settle, reasonably oil free, to the bottom. Usually the bulk of the soaps will settle quickly while the smaller portion will take hours, and toward the last a haze, carried by the convection currents in the hot oil, will rise and stay in the oil until it is either blown bright or taken out by subsequent washes.

That is one case—perhaps the most common of all. On another batch, treated, and on the face of things handled in exactly the same manner, the milk-water will break and settle clear from the top. The bulk of the soaps will settle slowly, the fine emulsion particles being picked up and carried down while the oil is left clean, even brilliant. The total settling time on a batch of this sort will be found to be less than in the first case where the first soaps dropped out quickly. In a tall agitator there is always a slight rise of haze due to heat currents, but this is much less in the last case than the first.

In the mine mill the parallel of this condition is the settlement of a graduated mixture running from a fairly coarse sand to the finest of slimes. Here as in our first case the heavy parts will drop out one after another, leaving the slimes to settle slowly if at all.

The controlling factor in settlement, whether it be of an emulsion or a slime, is the force of gravity. If this slime is to be settled at a reasonable rate we must increase the size of its particles. To accomplish this we can add slow settling materials, which as they go down, will pick up the slime particles and carry them along. Or we may delay the settling of the coarser particles so that they will have the same effect. Controlled agitation also goes far to increase the particle size and give improved settling conditions.

The same general proposition holds for the settlement of soaps from oils that are being washed. In our proposition this means that the soaps must be of such a gravity that they will settle at the desired rate. In order that this will be accomplished it is necessary that the correct proportion of water be present when the washing begins.

To determine this correct proportion some of the oil which has been neutralized and is ready for washing should be brought into the laboratory. A laboratory treat should not be taken, but one from the plant agitators. Several washes should be tried, using different proportions of water. Then the proportion that gives the best results may be tried in the plant. Probably it will not work the first time but the small scale work gives a starting point which may be modified to meet large scale conditions. In this way it is entirely possible to establish a washing proceedure for any grade of oil which will hold reasonably close for all batches treated and will give improved results both in the quality of the oil and in the plant operation.

Where live steam is employed for heating and agitating the batch, the methods in general use are somewhat against the maintenance of a constant water proportion. The quality of the steam varies, the steaming time is not the same for every batch, and weather conditions will cause large variations in condensation. In

many cases the treater can make a fair guess as to the condition of his batch and shut off the steam, but it is really not necessary to run this part of the job by instinct alone. With live steam it is possible to determine the proportion of water necessary for the best settling conditions and then carry on the steaming, after a part of the necessary water is added, until the determined level is reached in the agitator. This means some trial determinations to fix the quantity of water to be added before the steaming begins. In setting this quantity reasonable steaming time must be allowed before the finished level is reached in the agitator. The above is the practice with many concerns and can profitably be taken up by anyone using live steam for washing neutralized oils. It will be seen that by this method, regardless of the quality of the steam, the weather or other variables, the water content of the mix may be kept constant, the settling rate held so that everything will go down in the shortest possible time and that none of the slower settling particles will be left up in the oil.

Another method of increasing the weight of the soaps is to change the strength of the soda. In this matter of soda strength there are two considerations involved, the one of settling as rapidly as possible and the one of getting as much washing effect as possible out of the original washing solution. It is a fact that an oil which has been neutralized with a stronger soda solution will require more washing than one which has been neutralized with a solution of a strength of 2° Be., but in many cases it is preferable to use the stronger soda for neutralization and then by the addition of the proper amount of water get an adjustment which will give thorough washing and good settlement.

It must be kept in mind that the washing of an oil, and this applies particularly to cases where more than one wash is used, is not just a matter of adding unlimited water and steaming indefinitely. Unless conditions be such that the wash settles clean the excess water is of little value. Many times it is possible to improve washing by actually cutting down the wash water to bring the balance between the oil and the soaps present to such a point that the latter will settle clear. And it must be noted that the things which make for clean settlement also go far toward predetermined operation and a considerable saving of time.

In discussing the determination of the quantity of wash water to be added it may be well to look into the differences between laboratory settling condition and those of the plant agitator. In many cases the laboratory settlements will be perfect. After the first wash the oil will be free from haze and brilliant. When this particular treat is carried to the plant it usually does not work out at all. As a matter of fact there is no good reason why it should.

In the laboratory the settlement is usually carried out in a beaker or in a small agitator. The depth of the mix will roughly equal the diameter of the vessel, generally less, seldom more. The hydraulic head in the laboratory settlement as compared with the plant agitator will be a matter of a few inches as against 30 to 40 feet. Where the experimental settlement is carried out in a hot room or a hot closet, the temperature will be uniform on the sides, the top and the bottom. Few, if any, heat convection currents are set up. In the agitator—even assuming it to be insulated—the outside is certain to be slightly cooler than the center of the batch. The material settling from the height of the agitator is certain to develop a considerably greater velocity than the material which settles in the beaker. In combination with the temperature differences this velocity sets up well defined vertical currents throughout the agitator and these currents develop sufficient force to carry up the lighter, slower settling material. As the batch cools and the heavy soaps go down this material shows up as a haze or light emulsion which often is not easy to wash out.

What would the miner do in case like this? In the first place his experience would teach him not to carry out the settlement of such material in a tall narrow tank. He would use a broad tank, probably of greater diameter than its height. But, having the tall agitator he would first determine the conditions in it which work against clean settlement, and then would adjust the gravity of his soaps until they would settle against any rising currents, and would carry down any fine suspended material. This is not impossible. As a matter of fact it happens every time a batch settles clear and bright. It means that the condition of the soaps must be such that the settling rate is slow enough to carry everything down. The problem, of course, is to make this a predetermined proceedure and not just a matter of chance.

It must be stressed here that the general practice of settling emulsions and soaps in tall, narrow agitators is not good. In batch acid treating there is some excuse for this as such a tank is almost necessary for the agitation required in the treat, but in the neutralization and washing the job can be handled much better in a low, broad tank. The Parral tank type of agitator, to be shown later, operates very efficiently in this type of tank and the lower settling height not only gives faster settling but greater clarity to the oil, as it is almost free from troublesome convection currents.

The slimes in the oil business which are handled by batch settling are few. There are the suphide sludges from doctor treatments, lime sludges, and sediments in cracking still tars, but all of these can be handled better by continuous than by batch processes of settling.

CONTINUOUS SETTLING

Continuous settling has been slow in coming to the oil business. Several things have contributed to the development of such processes in hydro-metallurgical work: the necessity for low costs in handling materials which had little value; the isolation of mining opera-

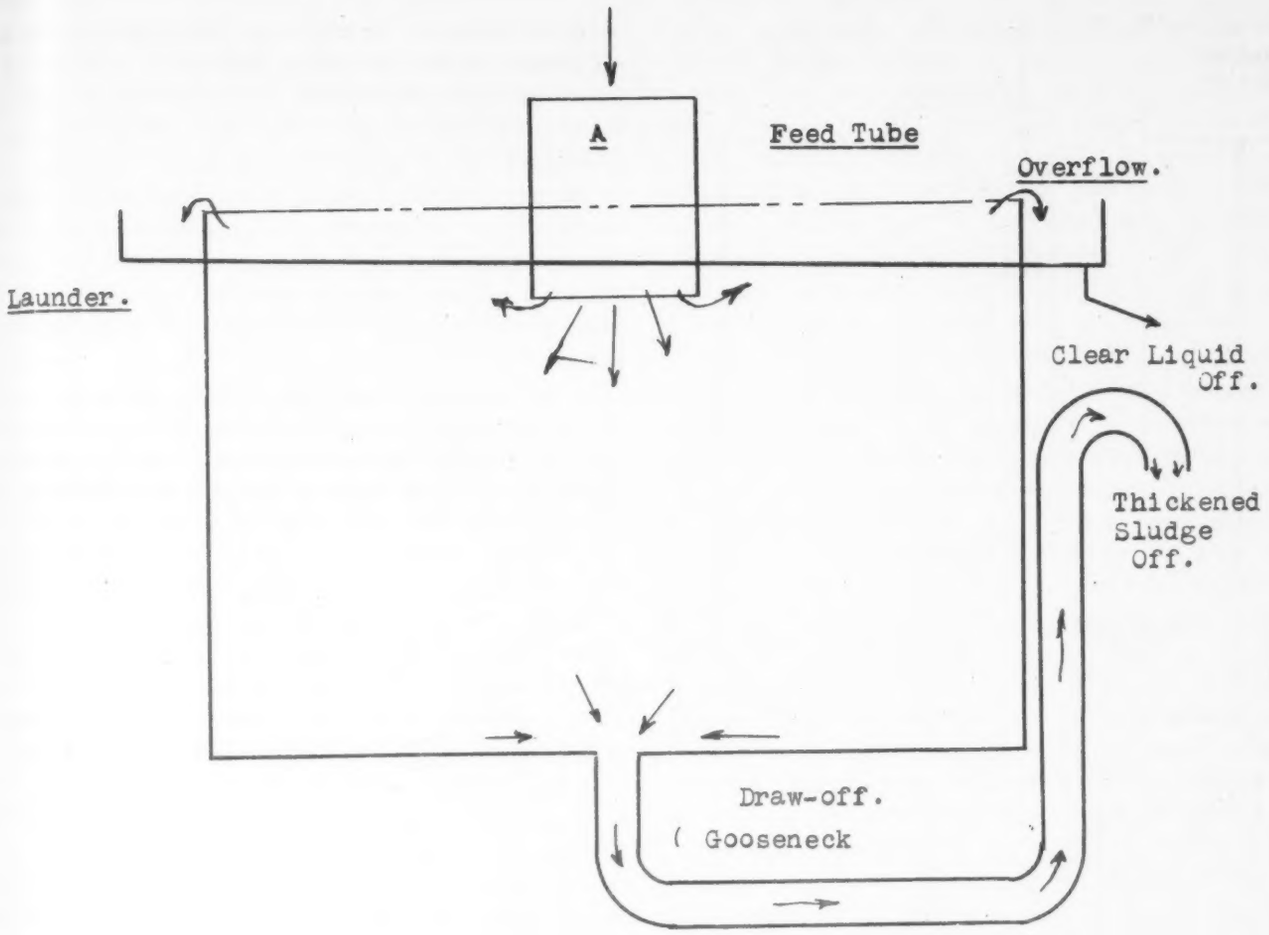


FIGURE 1
Typical continuous settler diagram.

tions which made it necessary to keep labor requirements as low as possible; and once the development of such processes was began, the increase in yields and in the value of metals recovered gave added impetus to the movement.

The general conception of the best conditions for settling is that the mix to be settled shall be kept absolutely quiet. This is not exactly correct. Provided that there are no eddy or cross-currents to keep the fines stirred up, materials will settle, even against a rising current. Naturally this current cannot be so swift that it will carry up the settling particles, but the fact remains that the mix is not necessarily quiet, that feed may be coming in, heavy slurry may be drawn off the bottom, and clear liquid may overflow all at the same time. Figure 1 represents the top of a continuous settler. The tank itself may be round or square; it may be cylindrical or conical, but the construction of its top and the principals of its operation will be the same in any case.

Here the feed comes in through the feed tube "A" located in the center of the tank. This tube is a large diameter pipe and it dips about 12 inches below the surface of the liquid in the tank. It may be provided with screens and baffles to break the flow of the feed and prevent disturbance as it enters the tank. In this tank we have a graduated condition. The heaviest, most compact part of the settlement is of course at the bottom and the draw off is set to deliver continuously a slurry of the desired quality. The settlement grows less compact farther up in the tank and at the top, just under the feed tube, the lighter more slimy portions will be concentrated.

Aside from settling alone, two things which are not present in batch settling operations assist in the flocculation of the slimes or fines in a continuous settler. The fact that the incoming feed keeps the slimes concentrated provides a condition which tends to cause them to flocculate and the particle size to build up to a point where it will drop. The incoming feed also distributes the heavier material at the top. This must settle through the concentrated slimes and in doing so it carries them along with it. Even in cases where the settler is provided with revolving rakes for pulling the settled slurry to the draw off pipe in the center of the tank, this slow motion in one direction around the tank delays the settling of the coarse material and thus assists in the flocculation of the fines.

In a settling tank the miner seldom attempts to draw off his clear liquid from a pipe or opening at one side of the tank. Such an arrangement sets up cross currents at the top of the tank where conditions should

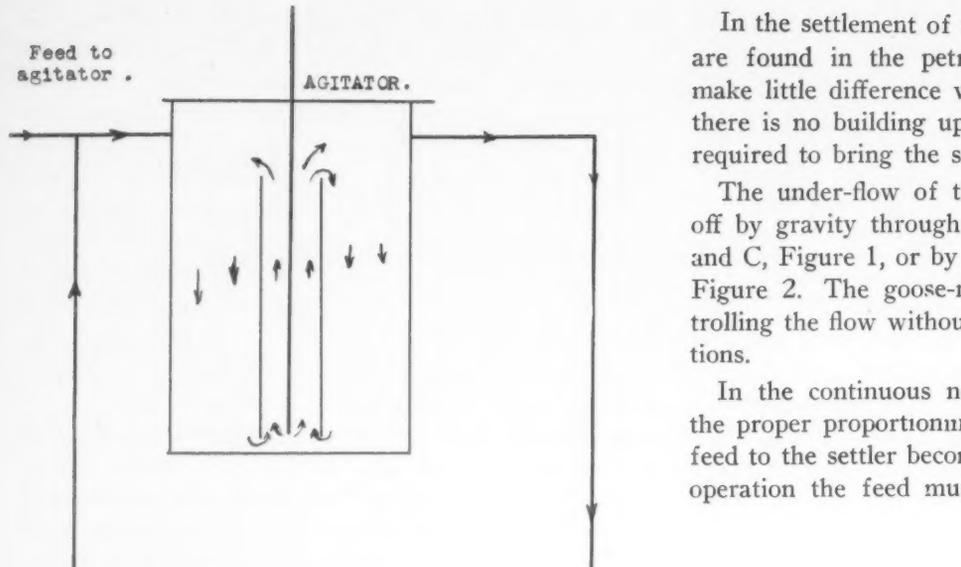


FIGURE 2

Hook-up of agitator and settler for feeding back under-flow

be as quiet as possible. Every effort is made that the movement of material through the tank will be a displacement rather than a flow. In order to meet this condition the discharge is over the upper rim of the tank. A comparatively shallow overflow over the entire periphery of a tank will give a considerable volume and yet will not cause cross currents.

At the top of every mixture as it settles will be found a thing layer of practically clear liquid. In a tank with an overflow of this sort this thin layer is kept skimmed off, the feed rate into the settler being set to give an overflow of the desired clarity.

Where slimes are being settled it is generally best to use a straight sided tank with rakes of some sort to pull the settled material to the center draw-off line. In the original continuous settlers conical tanks were used as such a scheme was necessary to bring the settled slurry to the draw off. Even with steep sides to the cones, however, slimes will build up on the sides, and shut-downs for cleaning are frequent. In addition, settling capacity is a function of the surface area of the tank. Settlers are often built 50 feet in diameter and larger. With an area as large as this a conical tank is almost out of the question, owing to its cost and the space required.

In the settlement of soaps and liquid sludges such as are found in the petroleum industry it will usually make little difference which shape of tank is used, as there is no building up on the sides and no rakes are required to bring the settled material to the center.

The under-flow of the settler may either be drawn off by gravity through the goose-neck as shown in B and C, Figure 1, or by a diaphragm pump as shown in Figure 2. The goose-neck provides a means of controlling the flow without using valves or other obstructions.

In the continuous neutralization of lubricating oils the proper proportioning of the water and soap in the feed to the settler becomes a necessity. For continuous operation the feed must be uniform and the settling qualities of the mix must not change every few hundred barrels. In batch operation one can put a batch into an agitator and wait until it settles, but this is not possible on a continuous job. In a continuous process it will be almost necessary to heat the batch through an exchanger rather than by the use of live steam. This removes several variables, as it is possible to use a given strength of soda, a given amount of water, and agitation can be controlled and the soap concentration held reasonably constant. In this way there should be no difficulty in keeping a feed of uniform settling quality going to the settler.

The conditions existing in a continuous settler working on slimes are duplicated when soaps are settled in the same equipment. We have the fast settling portions at one extreme and the haze or emulsion particles at the other. As with the slimes the continuous concentration of the fines at the top, and the continuous settling of the heavier portions through them, all tends to pull together the fine material and carry it down. At the top will always be found the thin layer of clear oil.

Under such conditions it would seem that application of the continuous settler to oil refining would follow the same principles as its application to the settlement of fine slimes.

It must be kept in mind that a continuous process is exactly what its name implies. It is essentially a large production proposition or at least one which calls for steady production with few changes in operating conditions. There are many oils which will not justify continuous production and which can be handled more economically by working them up in occasional batches. But in most cases the production of the refinery is well standardized and in the modernization of any plant the

question of continuous processing can be considered with profit. Just because the continuous neutralization of lubricating stocks and the continuous settlement of soaps has not been done to any extent is no reason for throwing them out of the picture. By turning to hydro-metallurgical work for ideas we find a long and successful experience which can easily be adapted to these problems.

Few slimes come into the refining business and these can all be handled by continuous methods. This is especially true with sulphide settlements from doctor treatments, lime sludges, and the settlements from pressure still tars. In handling material of this sort in the oil refinery it is not generally recognized that the particles can be built up to a point where it will settle, nor do the batch settlers generally used give sufficient opportunity for the material to flocculate or place it in a position where it may be carried down by other material settling through it. Further, it is not recognized that where such material is to be filtered this flocculation of the slimes not only makes filtration possible but also gives a cake which handles well on a filter.

In Figure 2 the hook-up of a continuous agitator and settler are shown. Here the feed enters the agitator and goes from there to the settler through the feed tube B. The clear liquid overflows at F into the launder C, while the slimes settle and are drawn off as underflow by the diaphragm pump E. This settled material will as a rule be well floculated and have a fair settling rate. Many fines are deficient in flocculated material and for this reason a certain portion of the underflow from the settler is returned to the agitator. In order to give the particles every chance to build up, the agitation must not be too violent. A few experiments will show the proper rate. By operating in this manner the feed to the settler can be built up to give the best settling conditions.

In some cases a flocculant or filter aid is added. This will be necessary in some cases but on the whole will prove more expensive than the feed back of settled material from the settler. When filter aid is used, too often it is fed into the mix just ahead of the filter, mixed in after a fashion, and then sent on to build up a cake. Even though a settler may not be used ahead of the filter it will be worth while to use some sort of controlled agitation in the mixing so as to get real flocculation. This will result in a much better flow rate and a much more open filter cake than when no special care is taken in mixing in the filter aid. A saving in the filter aid can also be effected by this means.

It must be kept in mind that any material added for flocculating purposes must be of such a nature that it will not settle too fast. It is the slower, more gradual settlement that pulls the slimes together and carries them down. For this reason it is especially desirable to feed back part of the underflow as this is already adjusted to the settling conditions of the particular job.

This proposition of feeding back settled material may also be used to help the settlement of soaps. Not in every case is it advisable to use a soap which has been broken out, as a flocculating agent, but where it can be done the idea works very well. As with a slime, only sufficient must be added to give proper settling and the agitation must be controlled in order that it will not mix back to form an emulsion.

At various times proposals have come up to use agents such as glue, floculant silica and aluminum compounds for carrying down the soaps. This practice has never been particularly successful as such coagulants are likely to promote the formation of emulsions and are harder to get out of the oil than the original soaps.

It has been proposed to use the feedback scheme for the settlement of acid sludge, for the flocculation of pepper, etc. With a very liquid sludge the idea may work. In most cases where it has been tried, too much sludge has been fed back into the mix, the agitation is too violent, and the batch settlement used is not conducive to the best results. Where water has been used in the original settlement of the sludge, caution must be used in returning it to the oil as the longer contact with the moisture may have broken down the sludge and driven out substances which will re-dissolve in the oil and cause trouble. It is of course out of the question to use most lubricating oil sludges as flocculating agents as they begin to harden as soon as they leave the agitator and are in no condition to be returned to the system. While, under present conditions the use of acid sludge as a flocculant has little place, with the introduction of continuous treating processes and continuous settling it is entirely possible that the proposition may be worked out for some special cases.

One case where acid sludge has been successfully used as a flocculant is in the removal of sediment from pressure still tar. As they exist in the tar these fines will not settle and are most difficult to filter. The value of the product does not justify any great expense for a filter aid and as the cokey sediment is to be used for fuel, the addition of any appreciable amount of mineral matter is undesirable.

To start, a very little sulphuric acid was added to the tar. This formed the sludge which was to act as the flocculant and probably in itself helped to pull the particles together. The quantity of acid need was carefully determined, the flocculation and settling of the sediment being the criterion by which this was judged. The treating part of the operation was carried out in mechanical agitators and the agitation was carefully controlled to give the greatest increase in particle size. Finally the sediment was settled in continuous settlers and the underflow was in such a condition that it could be easily filtered on a continuous drum filter. The overflow from the settler was a clear sediment-free fuel oil and the coke recovered from the filter could be

(*Continued on page* 316)

Enlargement of Gasoline Plant

Involves Changes in

Operating Practice

WHEN oil and gas production was developed southeast of Lefors, Southeastern Gray County in the Texas Panhandle, Shamrock Oil & Gas Company owned the major portion of the leases covering the pool, and built a plant to process the gas coming from its wells and those owned by offset producers. Oil and gas production in this area slowly declined, and due to this fact and that proration of oil was maintained together with the low gas-oil ratio, insufficient gas was produced to operate the gasoline plant distillation equipment to capacity.

Equipment included in the original layout consisted of five 200 horsepower gas engine-driven compressors, together with a single seven by 30 foot absorber, which is capable of stripping 10,000,000 cubic feet of gas under 25 pounds pressure, and three distillation units. These units were used in such a manner that the rich oil was distributed equally among the three distillation units in relation to their capacity. This condition continued until January, 1934, when the production of stabilized gasoline had declined to 3500 gallons, which gallonage was too low to justify operating the plant as a manufacturing unit. In the meantime, a large reservoir of gas had been tapped about six miles to the southeast, and preparations were begun to use it to supplement that being handled through the compressors.

Like all the gas produced in the Texas Panhandle, the gasoline content is very low in comparison to some of the gas processed in the Mid-Continent area, containing on an average of 0.564 gallons per thousand cubic feet. This applies to the entire Panhandle district, but variations occur where the content is much lower, and on the other hand, some localities produce a gas having a content in excess of a gallon and three quarts to the thousand cubic feet. However, in this particular locality, the gas available for processing through the plant as originally designed indicated a gasoline content of 0.40 gallons per thousand, and the high pressure gas developed later has a yield of only 0.26 gallons per thousand. Large volume, and that under natural pressure, is the only condition that permits processing of this extremely lean gas at anything like a profit, and some times the price of the finished product is so low that the plant "goes into the red."

Everything was on the ground and in place at this plant with which to manufacture a much larger amount of finished product. The pressure on this new gas field was high enough that the gas could be transported the six miles and processed through the plant under natural pressure, but to do so at the existing pressure held on the original equipment would make it necessary to install a number of low pressure absorbers and to pump and cool a very large amount of absorbing oil. Two hundred pounds was the pressure decided upon to contact the gas with the absorption oil, and high pressure equipment was decided upon to handle this situation.

Forty million cubic feet of this high pressure gas, based upon 25 percent of the open flow of the wells, was available. Field lines were laid from the wells to the plant, the equipment was erected, pumps installed and the necessary accessories placed in position at a cost of approximately $70,000.00.

The transportation lines coming into the plant yard carrying the comparatively lean gas are connected to a five by six foot preliminary scrubber to remove the field condensate and any foreign matter. This scrubber is provided with a drain connection set on an angle of 45 degrees, so that the inner end of the pipe contacts the conical base. All dirt, dust and scale can readily be removed when blowing the liquid and due to this feature, nothing can accumulate and gradually fill the base of the scrubber.

The scrubbed gas, after scrubbing and before entering the absorber, passes through two master meters, the volume being divided in a manifold so that each takes an equal part of the gas passing through. Immediately after leaving the metering manifold, the gas enters the high pressure absorber, a single tower six feet in diameter by 36 feet in height. This tower is welded throughout and has a working pressure of 300 pounds. No manholes are provided, but entrance may be made to it through the flanged and bolted upper head. Plates, downspouts and other equipment may be inspected, removed and cleaned through this arrangement. Gas

enters the base of this tower in the conventional manner, and at a field temperature, without cooling, of 52° F. Expanded from the wells and transported through deeply buried lines, the gas will not likely reach a temperature in the summer above satisfactory working conditions. The nature of the soil, a white caliche, lends itself to a fairly good insulating situation, and the heat of the sun does not penetrate to great depths where this soil exists.

The contact between gas rising through the tower, and the oil coming down is made through bubble plates and caps, and the outlet for the stripped gas is placed in the shell below the tower flange of the removable head. During February, 1934, the residue gas carried a content of 0.0046 gallons per thousand, indicating that practically all of the desirable fractions in the original gas had been extracted.

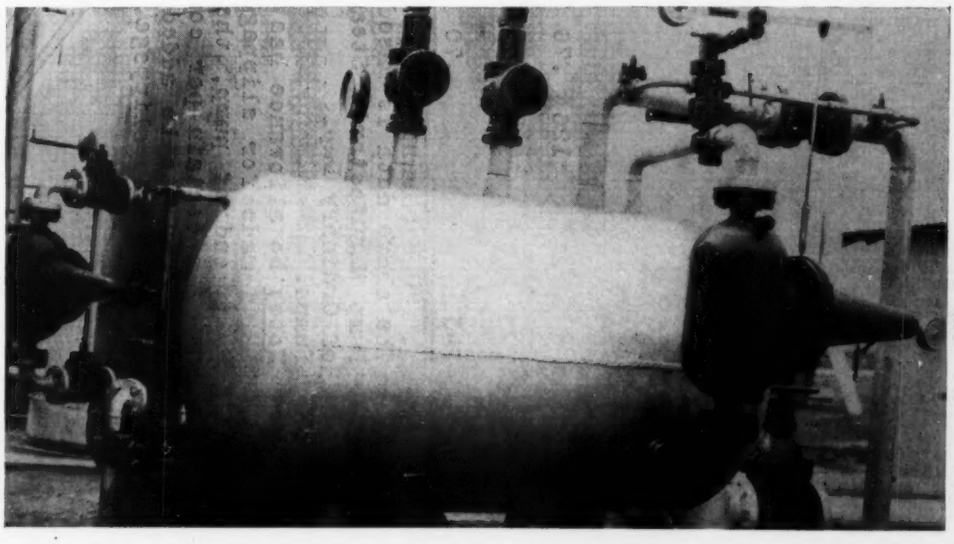
The rich oil is permitted to flow from the base of the tower through a high pressure liquid level controller which may be blocked off with lubricated plug valves. A pressure drop is intentionally provided across the valve, and the drop is from 200 to 75 pounds. Immediately after passing from the absorber, the oil enters a small horizontal vent tank where the vapors that escape from the oil under the lower pressure are vented to the residue lines. This venting is accomplished through the operation of another float control, closing and opening a valve in the vapor line as the rich oil in the vent tank fills or drains away.

Under the old system of operating the three distillation units, volume controllers were placed on the units to permit the rich oil from the absorber to flow to the three units in proportion to their size and capacity. When the new arrangement was completed, the two smaller units were separated from the larger and the latter was used to process the rich oil coming from the new high pressure absorber, while the two smaller stills were continued in the operation of the conventional low pressure absorber. Vented oil from the small horizontal tank flows directly to the distillation unit which is operated in a conventional manner, except that the fat oil pumps are not used; the oil having sufficient pressure coming from the absorber and vent tank to drive it through to the lean oil surge tank. At this point, it is picked up by one of two reciprocating pumps operated by gas from the absorber pressure. The oil is cooled through a series of Bentube sections, rearranged for high pressure service, that were used in the old installation to cool some of the gas from the compressors.

Oil handled by these pumps approximates three gallons per thousand cubic feet of gas passed through the high pressure absorber, and after being cooled to an average of 60° F., enters the absorber near the top. The saturation permitted in the tower runs on an average of 12 percent.

The operations of the original low pressure units were not changed appreciably except rearranging for accommodating the high pressure installation. The two rearranged units, high and low pressure, work independently of each other, except that the condensate from both enters a common accumulator tank. Before the installation of the addition, the gross stabilized production had dropped to 3500 gallons, but after balancing the operation of the new unit, production had risen to 12,500 gallons. Plant efficiency is excellent, for based on the figures given, the factor is around 1.7.

No recompressor is or has been employed to salvage the vapors from the run tanks, but instead a small reabsorber was installed in the original layout through which these gases are passed in counter current to a split stream of lean oil from the low pressure pumps to extract the desirable fractions. Gasoline from the common accumulator is fractionated to the desired vapor pressure and passed to storage.



Details of control system for operation of rich oil vent tank.

Steam Per 100 Gallons Oil Pumped
Total Working Oil Pressure at Pumps
Total Working Oil Pressure at the Pump (Including Suction)
Steam Per 100 Gallons Oil Pumped
Pumps
Steam Rated Steam Per I.H.P. Mech. Liquid Eff. H.P.
18-14-24 } 15-10-24 } 110 .85 130#
15-10½-18 } 12-10 -18 } 12 -8 -18 } 110 .82 135#
8-8-12 } 8-6-12 } 121 .78 155#
7½-5-10 126 .76 165#
6-4-6 180 .72 250#
3-2-3 180 .70 260#
The above data is based on the Pump Manufacturer's Steam Consumption of Ordinary Duplex Direct-Acting Pumps.
Note: No allowance has been made for slippage on oil end of pump, therefore a certain per cent will have to be added to include slippage.
15-10-24 Pumps
12-10-18 "
8-8-12 Pumps
6-4-6 "
3-2-3 "
0% Slippage
5% "
10% "
The above data is based on the
Formula:- H.P = .000583×P×Gal per Min / L
and developed to the
Formula:-Steam = .000972×P×St per HP / L
100 gals
By J.Y.Olsson, Bayonne Refinery

Graphical Chart for Steam

Used in Direct Acting

Steam Pumps

J. Y. OLESON

Engineer-Statistician, Standard Oil Company (New Jersey) Bayonne Refinery

FORMER articles in the "Refiner" have shown the method of constructing graphical charts for refinery uses. In this article is shown the actual derivation of the equations to be used in making the graphical charts showing the approximate steam used in various direct acting plunger pumps.

The well known equation of horsepower will be used as a base to determine the other required equations.

$H.P. = \frac{P L'' A N}{33{,}000}$ in which P=pressure per square inch. L"=length of stroke in feet, A=area of cylinder in square inches, N=number of strokes per minute.

This equation becomes $H.P. = \frac{P L'' A N}{396{,}000}$ when the length of the stroke is given in inches, then L"/12=L and L" A N=cubic inches of liquid pumped per minute, therefore $\frac{L'' A N}{231}$ = gallons pumped per minute. Then the value of L" A N = 231 times the gallons per minute. Then

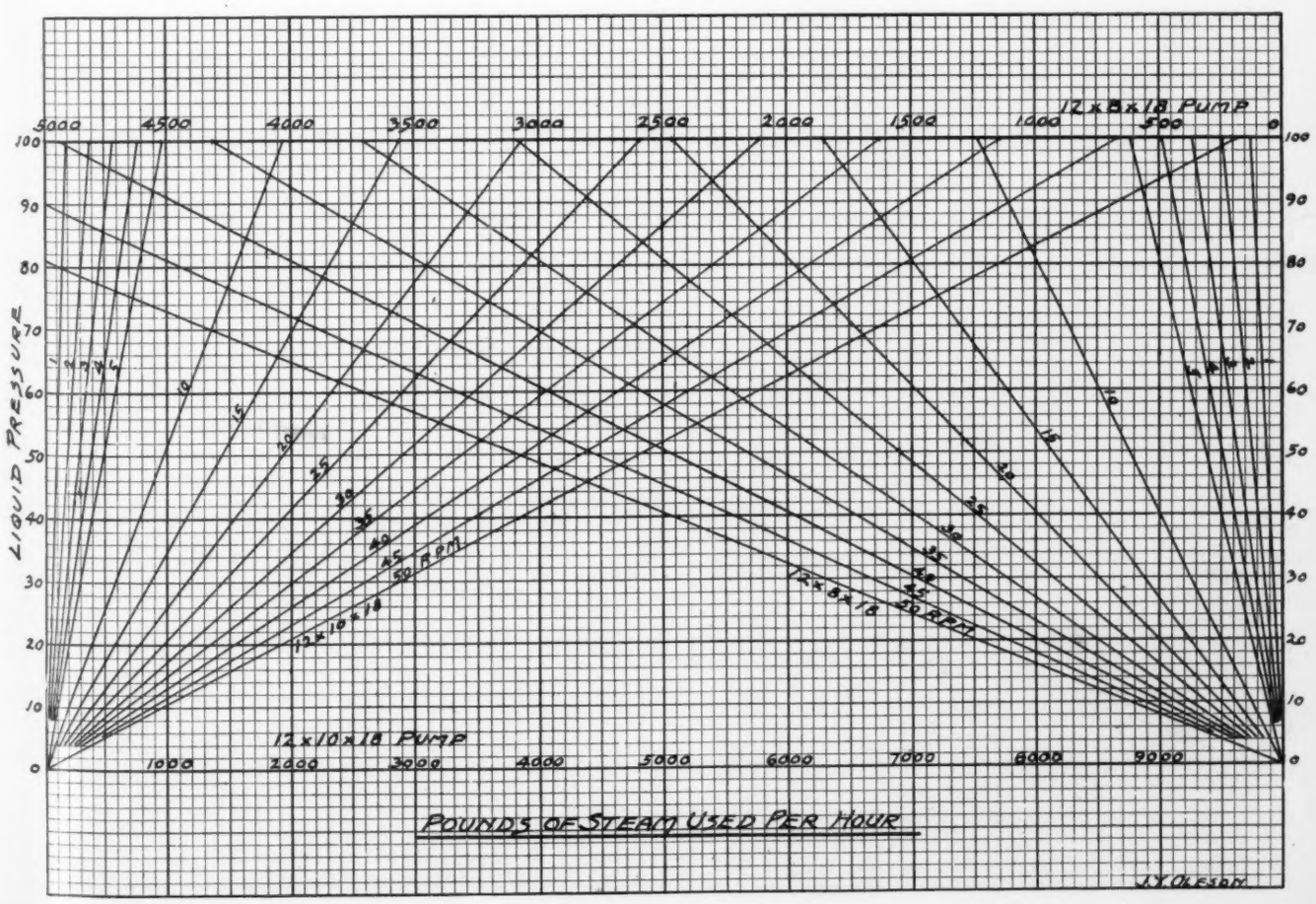
$$H.P. = \frac{231 \text{ P times gallons pumped per minute.}}{396{,}000}$$

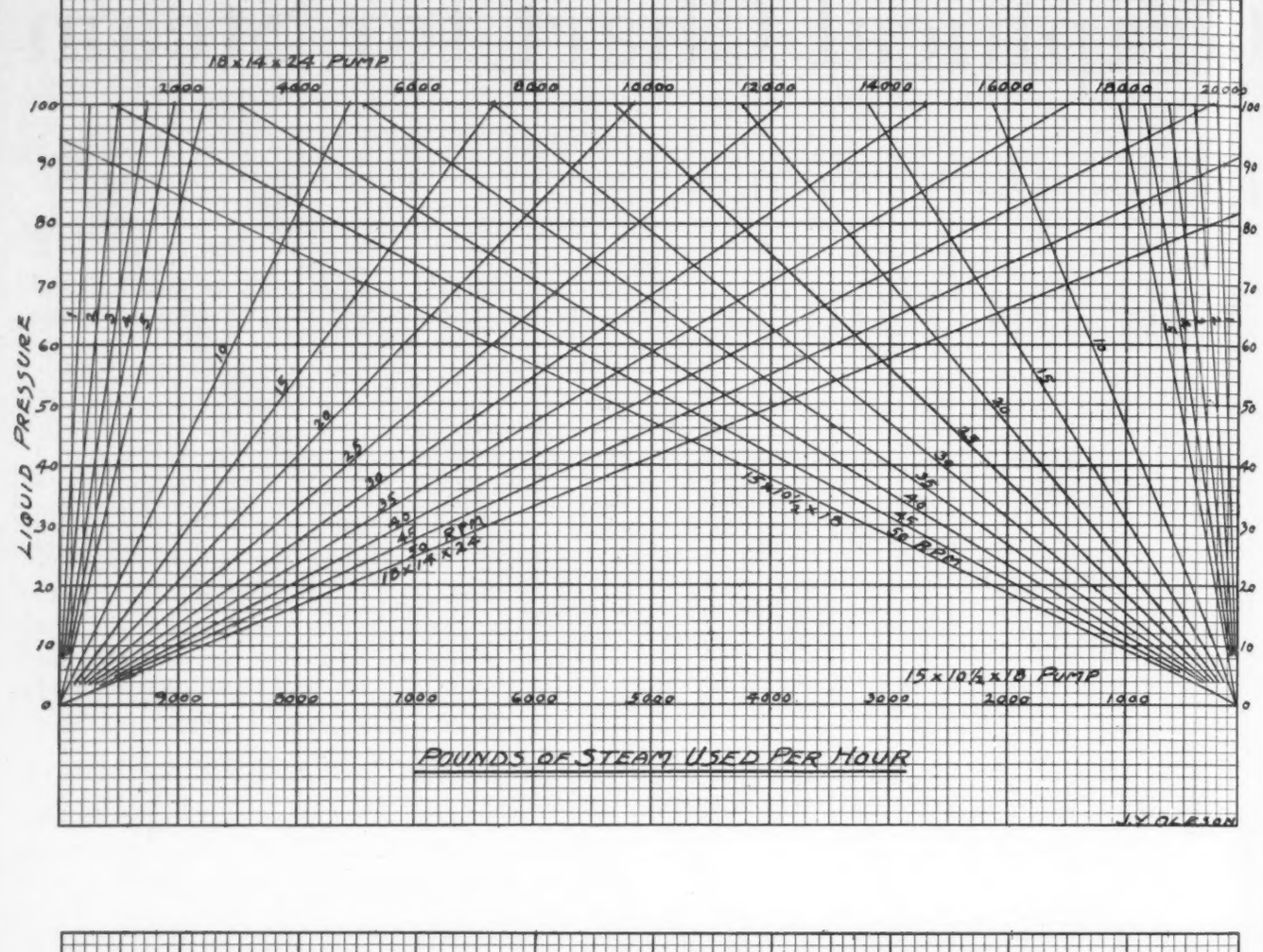
H. P. = .000583 P times gallons pumped per minute.

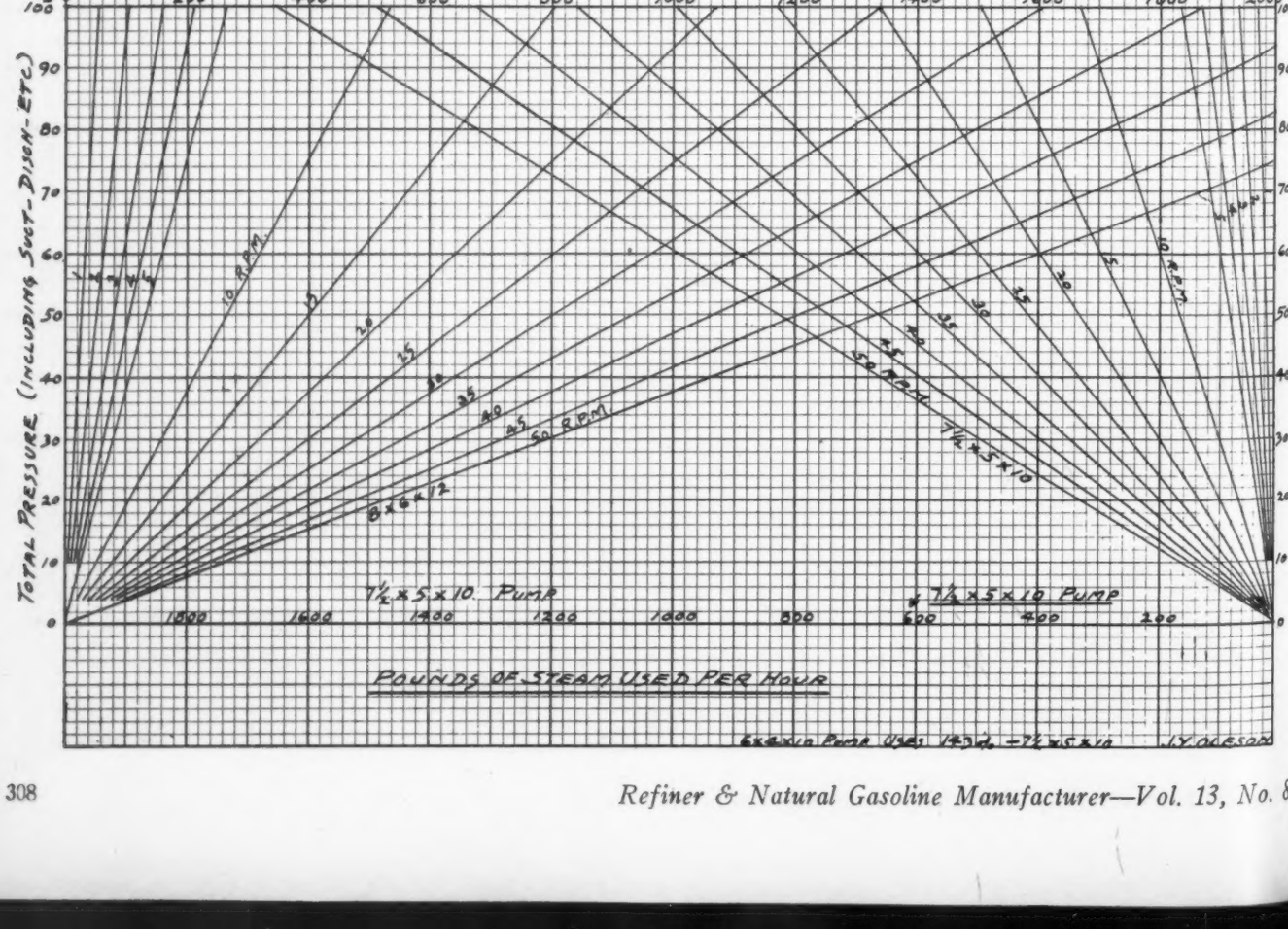
This equation shows that the horsepower is equal to a constant (.000583) times the pressure and gallons pumped per minute. The gallons per minute is equal to the amount pumped per hour divided by 60, and by substituting this for Gal/Min the equation becomes

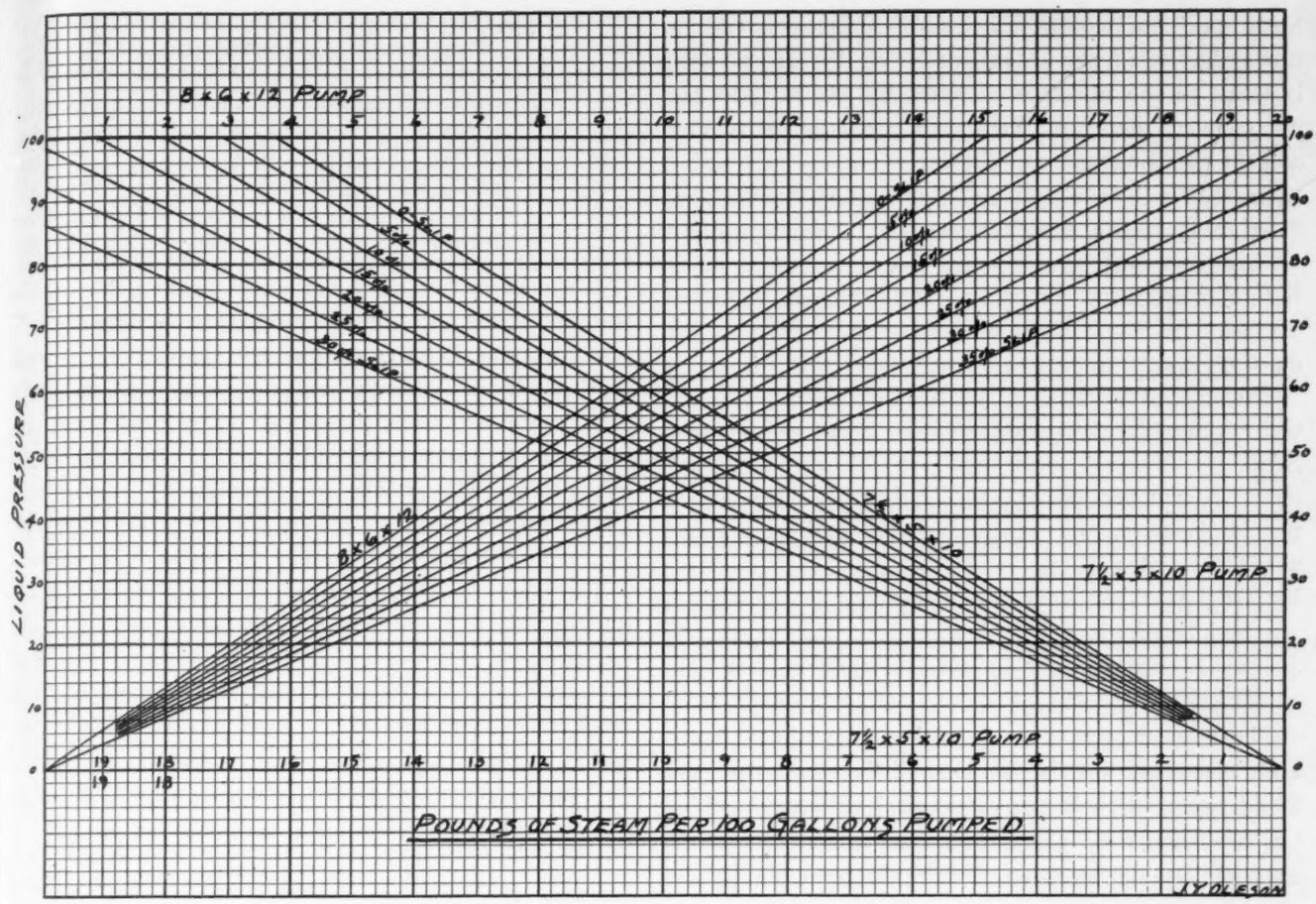
"A" $H.P. = .000583\ P \frac{G/hr}{60} = .00000972$ P gals. per hr.

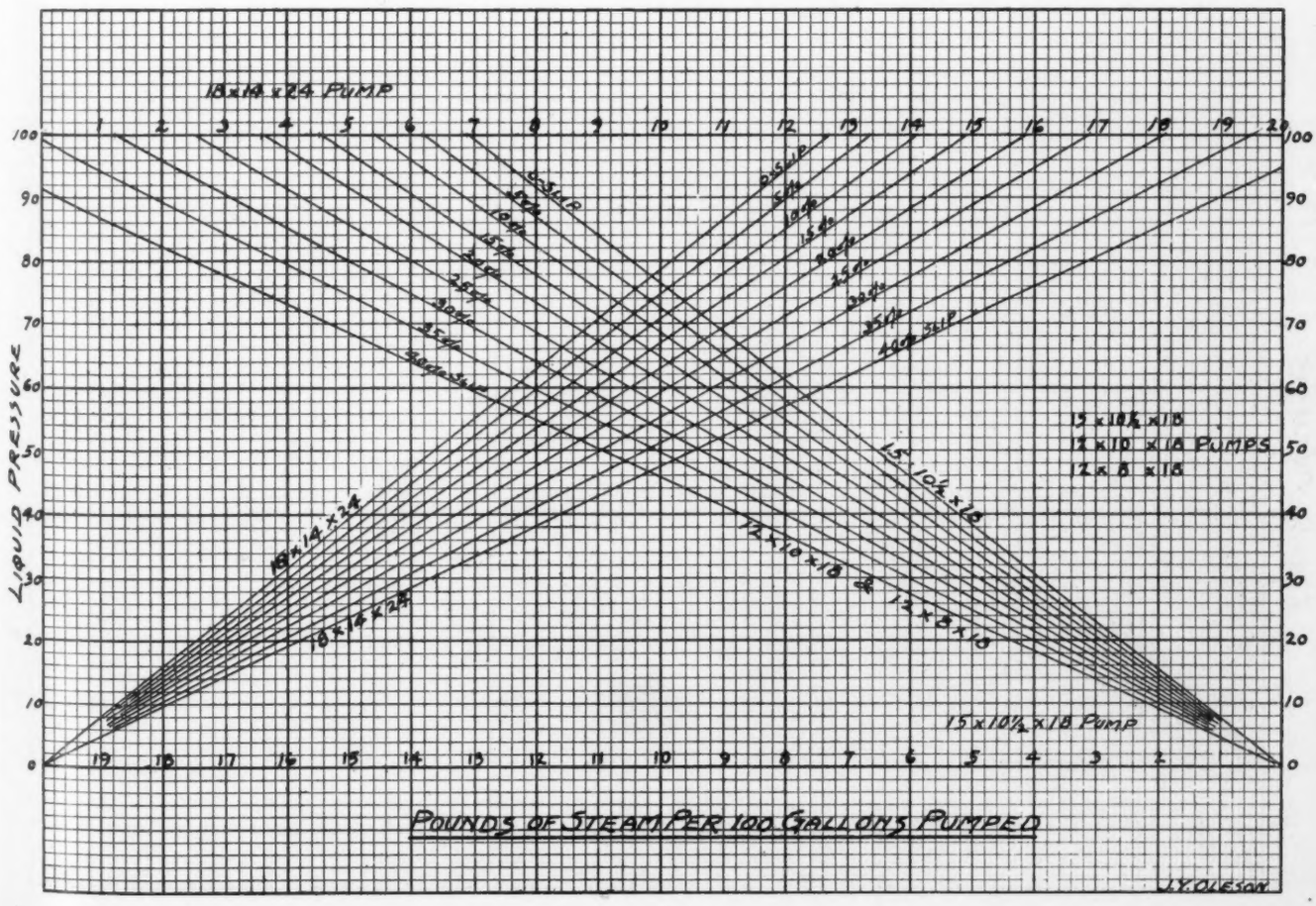
The above equation is further developed to indicate the steam used per gallon of liquid pumped. The steam used per hour is equal to the hourly gallons pumped




18 x 14 x 24 PUMP
LIQUID PRESSURE
15 x 10½ x 18 PUMP
POUNDS OF STEAM USED PER HOUR
J.Y. OLESON


6 x 6 x 12 PUMP
TOTAL PRESSURE (INCLUDING SUCT.-DISCH.-ETC.)
7½ x 5 x 10 PUMP
POUNDS OF STEAM USED PER HOUR
J.Y. OLESON


8 x 6 x 12 PUMP
LIQUID PRESSURE
POUNDS OF STEAM PER 100 GALLONS PUMPED
8 x 6 x 12
7½ x 5 x 10 PUMP
J.Y. OLESON


18 x 14 x 24 PUMP
LIQUID PRESSURE
POUNDS OF STEAM PER 100 GALLONS PUMPED
15 x 10½ x 18
12 x 10 x 18 PUMPS
12 x 8 x 18
15 x 10½ x 18 PUMP
J.Y. OLESON

Steam per hour=.00000972 times P S/hp times Gal/hr times the steam per gallon, and also the steam used is equal to the horsepower times the steam used per horsepower, therefore, these are equal to each other and the equations are as follows:—

S/hr=G/hr times S/gal and S/hr=H.P. times S/hp. Therefore:—G/hr times S/gal=H.P. times S/hp and

$$\text{H.P.} = \frac{\text{S/hp}}{\text{G/hr times S/gal}}$$ and substituting equation

"A" .00000972 P times G/hr$=\frac{\text{G/hr times S/gal}}{\text{S/hp}}$ and G/hr times S/gal=.00000972 P times G/hr times S/hp.

"B" Steam per gal=.00000972 times P times Steam per horsepower, and Steam per 100 gallons pumped =.000972 times S/hp.

P=Total working liquid pressure at pump (Discharge and Suction).

S/hp= Steam used per Liquid Horsepower (See data below).

The manufacturer's steam rating of various pumps are given below for the I.H.P., and the steam used per liquid horsepower is the mechanical efficiency divided by the steam used per I.H.P. The amount of steam used per liquid horsepower by the different pumps and also the steam used per 100 gallons at 100 pounds liquid pressure is as follows:

Stroke	Steam Per I.H.P.	Mech. Eff.	Steam Per Liquid H.P.	Steam Per 100 gals at 100lbs. Pres.
24″	110 lbs.	.85	130 lbs.	12.64 lbs.
18″	110 lbs.	.82	135 lbs.	13.12 lbs.
12″	121 lbs.	.78	155 lbs.	15.07 lbs.
10″	126 lbs.	.76	165 lbs.	16.04 lbs.
6″	180 lbs.	.72	250 lbs.	24.30 lbs.
4-3″	180 lbs.	.70	260 lbs.	25.27 lbs.

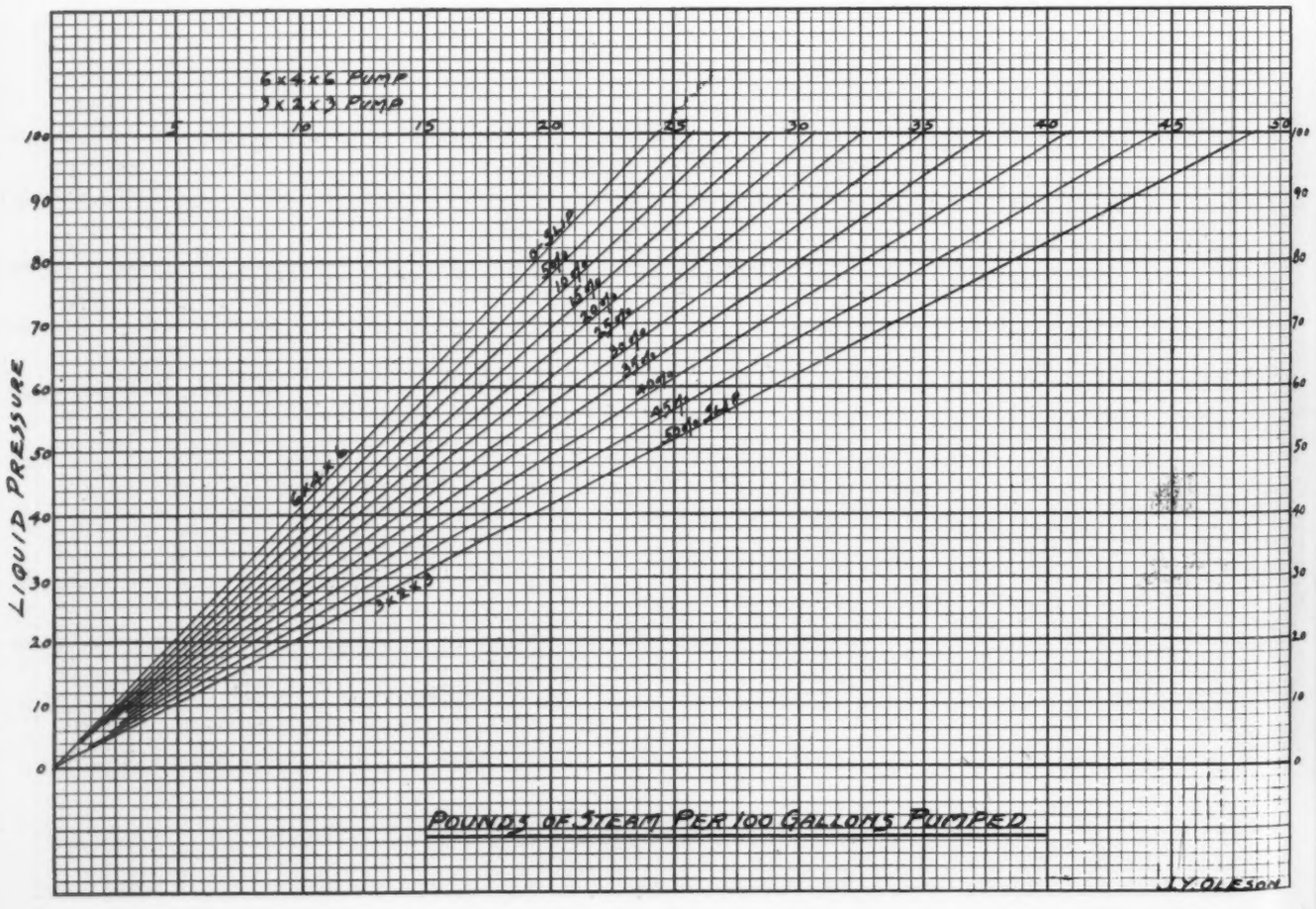
The data in the last column was computed from the equation "B", and these figures can be used to construct graphical charts as shown in this article. A general graph for various pumps is submitted, and this data is based on zero slippage. Therefore, proper allowance for slippage should be made when using this chart. The individual graphs indicate the steam used at various percent of slippage, and these are apparently the most convenient to use for steam distribution.

The above computations have shown how to derive the equation for computing the amount of steam used for pumping on basis of gallons, and the derivation of an equation to compute the hourly steam used will now be shown. The equation "B" will be used as the base and is as follows:

"B" Steam per gal=.00000972 times P times S/hp, also

Steam per gal$=\frac{\text{Steam used per hour}}{\text{Gallons pumper per hour}}$ and therefore

$\frac{\text{Steam per hour}}{\text{Gallons per hour}}$=.00000972 time P times S/hp



Gallons per hour=Stroke per minute times $\frac{60\ L''\ A}{231}$

=.25974 times Stroke per minute times L″ A

Steam per hour = .00000972 times P S/hp times .25974 L″ A St/min. = .000002525 times P times S/hp times L″ A St/min.

Substituting for Strokes per min (St/min)=4 times R.P.M.

"C" Steam per hour=.0000101 times P times S/hp times L″ A R.P.M.

S/hr=Steam used per hour.

Gal/hr=Gallons pumped per hour.

L″=Length of pump stroke (inches).

A=Area of liquid piston (square inches).

R.P.M.=Complete strokes per minute = ¼ strokes per minute.

The computation of the hourly steam used by a 18/14/24 pump is as follows:

"C" Steam/hr=.0000101 times P 130 lbs. times 24 times 153.94 R.P.M. = 4.851 times P times R.P.M. (18/14/24 pump).

Additional Pump Equations (See table for steam per H.P.) = S/hp.

Steam per hour

=2.1253 times R.P.M. times P (15/10½/18) Pump

=1.9276 times R.P.M. times P (12/10/18)

=1.2338 times R.P.M. times P (12/8/18)

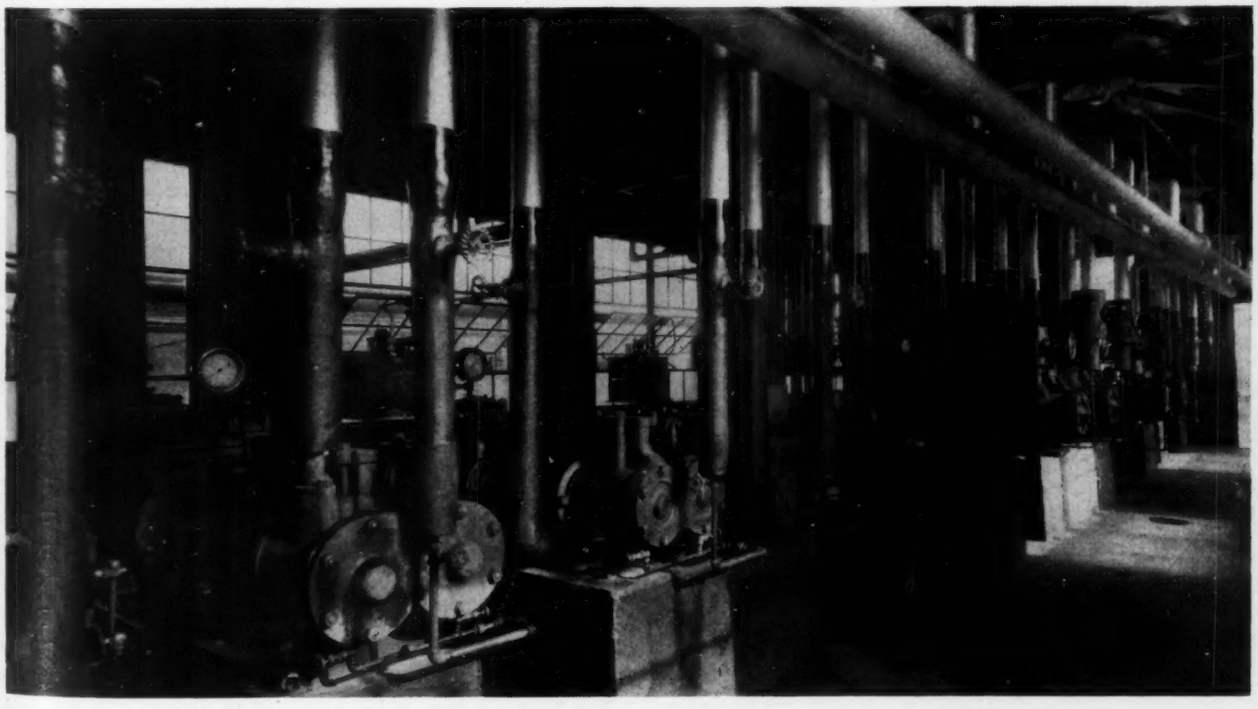
=0.5311 times R.P.M. times P (8/6/12)

=0.3273 times R.P.M. times P (7½/5/10)

=0.1904 times R.P.M. times P (6/4/6)

The above equations will furnish the necessary data to construct the graphs for determining the amount of steam used by the pumps. In a plant where the exhaust steam pressure is high the steam consumption will be increased and a proper allowance must be made in order to obtain the correct amount of steam from the graphs or equations. A very simple method of making a correction for this increase in steam is to add an additional equivalent pressure to the discharge (P) of the liquid pumped.

For example a 18/14/24 pump discharging oil at 55 pound pressure, and suction of 5 pounds, making a total working pressure of 60 pounds. The complete stroke per minute (R.P.M.) is 40 and the exhaust steam pressure is 12 pounds. The 12 pounds per square inch back pressure on the steam cylinder is equivalent to a 20 pounds per square inch on the liquid cylinder, and this is the amount to be added to the working oil pressure at the pump. The final equivalent pressure would be now 60 plus 20, or 80 pounds, and this would be the proper pressure to use in the equation or graph. However, the extra addition is not required where the pump steam is exhaust in the air or at a very low pressure.



Manufacture of ICE . . .

Using Stabilizer Reflux as Refrigerant

RUSSELL M. LILLY

THE supplying of ice for plant, laboratory and home use has always been more or less of a problem for the natural gasoline industry. The plants usually are located far from settled towns or cities and the difficulties and expense involved in daily transporting a considerable poundage of ice over notoriously bad, and often impassable oil field roads, make the installation of refrigerating equipment a highly desirable plant accessory.

Fortunately, for this purpose at least, natural gasoline plants have as by-products, certain gaseous hydrocarbons which have very excellent refrigerating qualities. The application of these materials and their properties to the manufacture of artificial ice has enabled many operators to produce, cheaply and efficiently, the ice used by the plant and its employees.

Availability of these materials are too well known to need much discussion, but the principles involved in their practical application to refrigeration are not widely understood. It is the purpose of this paper to present such information as will enable an operator to calculate and design a refrigerating unit to meet his particular requirements.

The earlier ice-making installations used as a refrigerant the condensate from the high-stage re-compressors, allowing it to expand into a vacuum, through coils in a tank of brine. The heat absorbed by the expansion and vaporization of this liquid was sufficient to produce a very low temperature and, consequently, a considerable amount of ice. However, as this condensate often contained an appreciable amount of marketable gasoline, its use as a refrigerant fell into disrepute and the manufacture of ice at the plant declined considerably until the advent of the high pressure stabilizer.

This system of stabilization fractionates at high pressures and temperatures and allows a very sharp separation between the marketable and unmarketable portions of the raw natural gasoline. The marketable portions, consisting of pentanes and heavier fractions with just enough butane to make the desired vapor pressure, are withdrawn as a liquid from the bottom of the stabilizer.

The unmarketable portions leave the tower in a gaseous form, but the high pressures under which they are held allow them to be readily recondensed for use as reflux. Since these unmarketable portions consist almost wholly of propane and butane (the fractions with refrigerating qualities) a part of this reflux may be withdrawn from the accumulator and used as a refrigerant for the manufacture of artificial ice.

There are, of course, a variety of ways in which this reflux may be obtained and efficiently employed, but the method described herein is the most common and usually the most desirable. It is simple and inexpensive of construction, requiring no change in piping, no extra condensers or accumulators and no automatic controls other than those used on the stabilizer proper.

The flow diagram of the tower and refrigerating unit is shown in Figure 1. The overhead gases pass from the stabilizer into the reflux condenser, the temperature of which is automatically controlled by water valve A so as to condense only just enough liquid to maintain a certain level in the reflux accumulator. The automatic control is actuated by the rise or fall of this level, and any liquid removed therefrom will automatically cause the valve on the reflux condenser to open, admit more cooling water and condense more liquid to replace that removed.

This system of automatic control allows the refrigerant to be taken directly from the accumulator, pass through the pre-cooler and expanded from expansion valve B. The cold vapors leaving the brine tank pass back through the pre-cooler, cooling more incoming refrigerant, and thence to the plant vacuum line.

Various means are employed to collect or utilize the waste refrigerant, and of these, the practice of expanding into the plant vacuum system offers most advantages. It is a simple, effective and readily available method of collecting and disposing of the used reflux. It is especially desirable in small plants, as the waste refrigerant is re-processed and a portion of it soon returns to the stabilizer for re-use. Expanding into a vacuum is essential to successful operation where there is a large amount of butane in the reflux.

Where a large volume of reflux is available, some

operators endeavor to use the cold expanded gas at low pressures as fuel for the boilers, gas engines and camp houses. Offhand, this would appear to be an admirable way of efficiently disposing of the used reflux, but actually, a number of complications must be overcome by careful design and operation in order to make its application feasible.

EXPANDING UNDER PRESSURE

Good practice in freezing ice requires a brine temperature at least as low as 20° F. A study of Table 1 reveals the fact that at 1½ pounds pressure the boiling point of butane is 35° F., or 15° F. above the required brine temperature. It is obvious that at this temperature and pressure butane, to all practical extents and purposes, will remain a liquid and will have no refrigerating qualities therefore the presence of butane must be ignored entirely in calculating the refrigerating effect obtained from a given amount of reflux.

While the greater portion of the butane will be carried out of the cooling coils as a mist suspended in the gaseous propane, it is advisable, when expanding under pressure, to provide a means of removing any liquid butane that might become trapped therein.

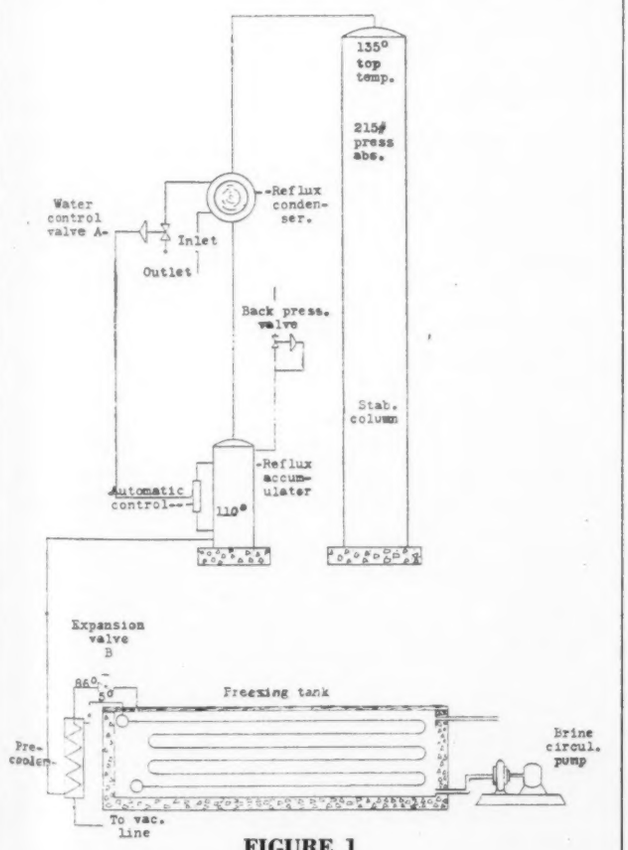


FIGURE 1
Flow diagram

TABLE 1

(Taken from Macintire's Handbook of Mechanical Refrigeration).

THERMAL PROPERTIES OF PROPANE

Boiling Point Deg. F.	Pressure lbs. per sq. in. Gauge	Heat Content in B. t. u. per lb. of		Weight in lbs. per Gallon	Molecular Weight
		Liquid	Vapor		
—70	15″ Vac.	—30.5	152.5	5.02	44.06
—40	1.5 lbs.	—21.5	160.0	4.83	
—10	17.0 "	—5.5	168.0	4.67	
0	23.5 "	0.0	170.5	4.61	
5	27.2 "	3.0	172.0	4.58	
10	31.3 "	5.5	173.5	4.56	
40	63.3 "	23.0	182.0	4.37	
60	92.4 "	35.0	188.0	4.24	
86	140.5 "	51.0	195.0	4.06	
100	172.0 "	67.0	201.0	3.95	
125	239.0 "	77.0	203.0	3.74	

THERMAL PROPERTIES OF BUTANE

Boiling Point Deg. F.	Pressure lbs. per sq. in. Gauge	Heat Content in B. t. u. per lb. of		Weight in lbs. per Gallon	Molecular Weight
		Liquid	Vapor		
0	15″ Vac.	0.0	170.5	5.16	58.08
5	13″ "	2.5	172.0	5.13	
10	11″ "	5.5	174.0	5.11	
35	1.5 lbs	19.0	183.5	5.00	
60	11.6 "	33.0	192.5	4.88	
86	26.9 "	48.5	202.0	4.73	
100	37.5 "	57.0	206.0	4.66	
125	61.3 "	73.5	215.0	4.50	

EXPANDING UNDER A VACUUM

Referring again to Table 1, it will be found that at 15-inch vacuum the boiling point of butane is 0°, or 20° F. below the required brine temperature. At this temperature and pressure butane will vaporize readily, with refrigerating qualities, and may be included in calculating the refrigerating effect obtained from a given amount of reflux.

The advantages of expanding into a vacuum are so numerous and apparent that it is almost universally used in gasoline plant refrigeration. All calculations will therefore be based upon a 15-inch expansion pressure.

With an exact knowledge of the quantity and composition of the reflux, it is possible to calculate very accurately the amount of ice that may be manufactured therefrom. A fractional analysis of the charging stock and reflux is, of course, the ideal method of obtaining the desired information, but as this determination requires a skillful technique and delicate and expensive scientific equipment, it is not usually available to the plant operator. In its absence, a fairly accurate and very convenient indication of the reflux composition may be obtained by the use of the following formula, in conjunction with the top temperature of the stabilizer, the column pressure and a vapor pressure chart. The molecular percent of the propane and butane as obtained thereby may

be readily calculated into percent by liquid volume.

$$\frac{A-B}{A-C} = D \text{ or the Molecular \% of Butane}$$

$$100\% - D = \text{Molecular \% of Propane}$$

In which A = Vapor pressure of Propane in pounds absolute at top temperature.
B = Column pressure in pounds absolute.
C = Vapor pressure of Butane in pounds absolute at top temperature.
D = Molecular % of Butane.

This formula assumes two perfect gasses, and will naturally be in error as much as the vapor pressure of the foreign gasses present. These are generally quite small, but ample allowance should be made for their presence.

To determine the possible production of ice per day of a unit, there must be known the amount of raw stock charged to the stabilizer, the amount of finished gasoline, and the quantity and composition of the liquid reflux. As an example, and in order to carry a calculation through to completion, it shall be assumed that the daily charge to a stabilizer is 16,000 gallons, the finished product is 12,750 gallons and the top temperature is 135° F. at a pressure of 215 pounds absolute. (200 pounds gauge.)

Refering to the Vapor Pressure Chart, Figure 2, it will be found that at 135° F. the vapor pressure of propane is 250 pounds absolute, and the vapor pressure of butane is 82 pounds absolute.

Substituting these figures for the symbols in the formula

$$\frac{250-215}{250-82} = 20.8 \text{ Mol. percent of Butane}$$

$$100.0\% - 20.8\% = 79.2 \text{ Mol. percent of Propane}$$

The molecular percent of propane and butane may be readily translated into percent by liquid volume as follows:

Mol. fraction of each component			Molecular Weight		Partial Weight		Total Wt.		Percent by Wt.
Propane	79.2%	×	44.06	=	3,489.6	÷	4,707.7	=	74.12%
Butane	20.8%	×	58.08	=	1,218.1	÷	4,707.7	=	25.88%
				Total wt.	4,707.7				

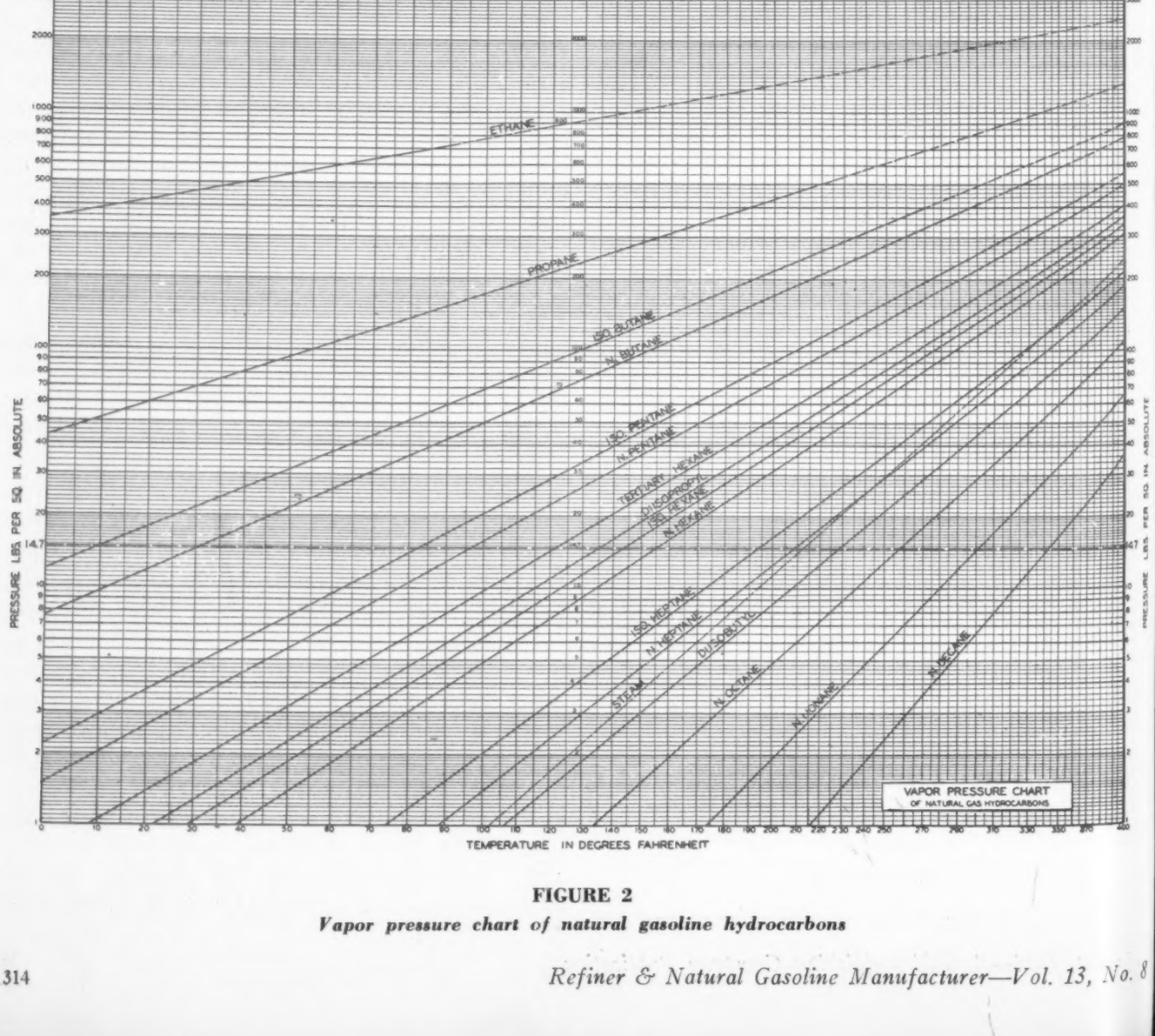


FIGURE 2

Vapor pressure chart of natural gasoline hydrocarbons

Assume one hundred pounds of this propane-butane mixture

Weight in pounds			Percent by weight		Pounds of each component		Lbs. per gallon at 60°F.		Gallons of each component		Total gals.		Percent each of liquid
Propane	100 lbs.	×	74.12%	=	74.12 lbs.	÷	4.24	=	17.48	÷	22.78	=	76.73%
Butane	100 lbs.	×	25.88%	=	25.88 lbs.	÷	4.88	=	5.30	÷	22.78	=	23.27%
								Total gals.	22.78				

With a feed of 16,000 gallons and a finished product of 12,750 gallons, there would be leaving the stabilizer, as a gas, 2,250 gallons per day of potential reflux. This entire amount, of course, cannot be fully reclaimed, and since, in the absence of a fractional analysis, it is impossible to estimate just how much could be recovered, the only alternative is to make ample allowance for the action of any dissolved methane and ethane and for any inefficiencies that might result from the extra load placed on the reflux condenser. Assuming that 60 percent of the potential is recoverable, (with anything like efficient operation this should be more than ample allowance for any losses) there would be available 1350 gallons per day of reflux for use as a refrigerant, 76.73 percent of which would be propane and 23.27 percent butane.

Propane-butane mixture, 1,350 gals.
× 76.73% propane = 1,035.85 gals. propane
× 23.27% butane = 314.15 gals. butane

From the thermal data contained in Table 1, it is possible to calculate the refrigeration obtainable from propane and butane under any temperature conditions that will be encountered in gasoline plant refrigeration. Quoting from Macintire's Handbook of Mechanical Refrigeration, "The amount of available refrigerating effect is the weight of the refrigerant in pounds, multiplied by the difference in its heat content upon entering and leaving the brine cooling coils." More simply explained—the heat content of the liquid before expansion is subtracted from the heat content of the vapor after expansion and leaving the brine tank.

Using standard refrigerating conditions (86°F. liquid temperature and 5°F. expansion temperature) and referring to Table 1

Heat content of gaseous propane at 5°F.	172.0	B.t.u. per lb.
Less heat content of liquid propane at 86°F.	51.0	B.t.u. per lb.
Latent heat available for refrigeration	121.0	B.t.u. per lb.

Treating butane in the same manner

Heat content of gaseous butane at 5°F.	172.0	B.t.u. per lb.
Less heat content of liquid butane at 86°F.	48.5	B.t.u. per lb.
Latent heat available for refrigeration	123.5	B.t.u. per lb.

Calculating the total refrigerating effect of the propane and butane as follows:

	Gallons of each component		Wt. in lbs. per gallon		Lbs. of each component		Latent heat available for refrig.		Total b.t.u. of each component
Propane	1,035.85	×	4.24	=	4,392	×	121.0	=	531,232
Butane	314.15	×	4.88	=	1,533	×	123.5	=	189,325
Total b.t.u. available for refrigeration									720,557

Allowing for some heat losses and unavoidable inefficiencies, it is necessary to absorb about 222 B.t.u. from a pound of water at 70°F. to transfer it to a pound of ice at 16°F. In commercial ice plant design it is customary to add about 20 percent to the above figure in order to allow a safe margin in the calculations. For various reasons[1] a 30 percent margin will be used in this paper. Two hundred twenty-two plus and additional 30 percent will be a 288 B.t.u. allowance per pound of ice to be frozen.

720,557 ÷ 288 = 2,502 pounds of ice production per day.

Since even a large natural gasoline plant will not likely require more than 1,000 pounds of ice per day, it is obvious that a plant of this size need not be restricted in its ice requirements.

These calculations are based on a once-through basis, as usually no particular attempt is made to reclaim any of the waste refrigerant. While it is true that when expanding into the plant vacuum system the expanded gas is re-processed and a portion of it is soon available at the stabilizer for re-use, this is incidental and not intentional except in small plants where the volume of reflux is not large. In such instances it is probably more satisfactory to install a small belt-driven compressor and operate from the line shaft to recover and re-use the refrigerant as in commercial practice.

Almost any system of producing vacuum may be used, the writer has been told of instances where the steam jet method has been used with highly satisfactory results. The steam coming into contact with the cold gas is condensed and trapped off and the boosted gas is used as low pressure fuel for boiler firing.

MECHANICAL DETAILS

In plant design it is customary to allow about 50 pounds of ice per day per family, 50 pounds of ice per day for each drinking fountain and from 150 to 300 pounds daily for laboratory use.

Ice cans may be purchased cheaper and better than they can be made at the plant shop, and they are universally of small size (usually for from 50 to 75 pounds of ice). This eliminates any problem of ice storage, the freezing time is quicker and the cans are not too large for one man to handle in removing and refilling.

Since the brine solution is heavier than the combined weight of the water and the can, it tends to buoy it up and hold it partially out of the freezing solution. To overcome this it is advisable to either add weight to the bottom of the can, in the form of

[1]Such factors as the use of distilled water, pre-cooling of the water, agitating it with air while freezing, removing the core, pre-cooling of the refrigerant, special equipment, skillful operation, etc., all tend to increase the efficiency of a unit and decrease the amount of B.t.u. required to freeze a pound of ice. In view of the fact that most gasoline plants make no attempt at such efficient installations, it is advisable to increase somewhat the B.t.u. allowance per pound.

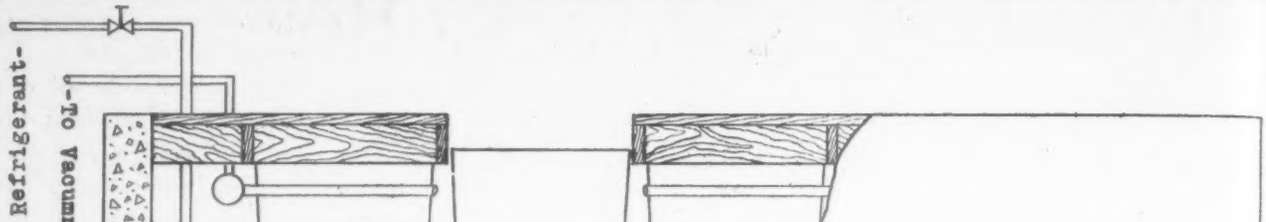


FIGURE 3
Coil and can arrangement.

lead or iron strips, or provide latches to hold the can well down in the brine solution. Such latches may be easily made from light hinges bent so as to hold the can.

The freezing vat usually consists of a waterproofed concrete tank, well insulated with felt or other material to prevent the entrance of heat. A double board covering is placed over the top, with individual openings and lids for each can.

The cans should be placed so that the large flat side will be next to the brine cooling coils, as in Figure 3, thereby allowing a quicker transfer of heat from the cans to the coils.

The brine should be circulated or agitated constantly, and every effort made to facilitate its moving freely to all parts of the tank. Unless care is taken in this particular, spots of still brine will collect between the cans and prevent the transfer of heat from them to the coils. The circulating pump should be well insulated to prevent the loss of cold.

The coils may be 1¼-inch pipe, placed lengthwise to the large side of the cans, and there should be about 350 lineal feet of pipe to each ton of ice capacity.

Sodium chloride (salt) brine is most easily obtained and likewise most commonly used. It should be made up to a Baume gravity of about 18 to 19 degrees. When circulating the brine it should be taken from the bottom of one end of the tank and pumped into the top of the other end.

Hydro-Metallurgical Methods Applied to Oil Refining

(*Continued from page* 303)

burned. This is an outstanding example of the application of the methods developed in metallurgical work to the petroleum industry.

In leaching and other metallurgical treating processes the use of continuous counter current settling has been carried to a high point of efficiency but there are few places where counter current flow can be applied to the methods used in oil refining at this time. Here again it is highly probable that the continuous treatment of oils with acids or with solvents will open a field to which the methods already well developed by the mining man may be applied.

All of the foregoing has dealt with settling, as that is probably the most important item that the two industries have in common. In metallurgical work, settling has been studied and equipment designed especially to facilitate it, to give the highest degree of clarification, to handle slow settling materials at the lowest possible cost.

The practical application of the principles of settling is not a matter of formula or of involved reasoning, but rather an application of sound common sense. Each case will have its own peculiarities, but as a rule a little experiment and thought will reduce most of them to common ground.

While settling is one of the most important items of both industries, there are other points of hydro-metallurgical work which can profitably be applied to oil refining. These will be discussed in the second part of this article.

Pennsylvania State College

Extension Classes in Petroleum *and* Natural Gas

G. O. EBREY
Chief Chemist, Pennzoil Company

THE Pennsylvania State College organized extension classes as early as 1893; this being the first organized extension service in the United States. However, classes in petroleum and natural gas were first held in 1933-34 with 11 classes in seven production and refinery centers in Western Pennsylvania, enrolling approximately 455 students. About 1275 men were enrolled in first and second year classes during 1933-34.

The classes bring instruction in these subjects to all who are interested. There are no definite requirements for entering the first course. The men enrolled are mainly those who have not had the advantage of technical training although some men have enrolled who have had engineering training; the course is largely review for these men. The first year of the three-year course is elementary and is intended to be preparatory for the second and third years which deal with petroleum production and refining, respectively. It is now hoped that eventually separate production and refining courses will be given in the last two years of the course.

The purposes of the classes are well stated in the preface to the texts which are used, viz., "The Extension Service of Pennsylvania State College is the medium through which the educational resources of the college are extended and made effective throughout the state. As a component part of a state institution, the School of Mineral Industries considers a portion of the normal function to be the collection and dissemination of relevent facts concerning the economic and scientific problems of the mineral industries and the relationship of higher technical education to the solution of these problems. Under the Federal Land Grant Act, accepted by the state, the Pennsylvania State College was founded to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." Extension classes have been established in accordance with the spirit of this act, also the college is authorized by the federal Smith-Hughes act to engage in extension activities. A group of 20 or more persons in any one school district may petition the college to provide instruction in any recognized subject.

This article will deal only with the extension works of the college in petroleum and natural gas although courses are given in other mineral industries subjects such as coal mining, metallurgy and ceremics. The course is formulated and outlined by the Division of Mineral Industries Extension in collaboration with an advisory board consisting of men associated with petroleum production, petroleum refining and natural gas companies. These men act in an advisory capacity to the staff of the School of Mineral Industries, who also prepare the text book material. It is in this way that a close relationship with practical industry is maintained. Text books for members of the class are supplied at cost; the local school board pays one third of the cost of the course, one third is paid by the state and one third by the federal government. The salary of instructors and cost of texts are practically the only expenses involved. The school board furnishes the meeting place which is usually in one of the local school buildings. One hundred twenty hours of classroom instruction is provided during a term. Twice a week meetings of two hours each for 30 weeks have been found most satisfactory in the Oil City classes. It has been the practice to begin the school work in October and finish the term in May or June. The instructors are usually selected from among local men who have had at least two years practical experience in the subjects which they teach.

The course in petroleum and natural gas is a basic three-year course, common throughout the state. The men who receive certificates for the first one or two units of the course in one locality, may enter the advanced class in that or any other locality for completion of the work.

The first year of the course includes mathematics, chemistry and physics; only the general principles are taken up. The practical application of these principles is always kept in mind. Among the subjects taken up in mathematics are: addition, subtraction, multiplication, division, fractions, proportion, square root, cube root, determination of areas and volumes, formulae, trigonometry, fundamentals of algebra, tables, curves and plotting. The chemical studies deal with the metric system, matter and energy, elements, compounds, mixtures, chemical and physical changes, fundamental chemical laws, gas, liquids, solids, atomic theory, chemical formulaes and symbols, the gas laws, heat, chemistry of common changes such as those occurring in

corrosion and combustion, solutions, and properties of the more common elements and compounds. The course in physics takes up stress, factor of safety, strength of ropes, chains and belts, fluids, liquids and liquid pressures, gas pressures, gas and liquid flow, expansion and contraction of gas, liquids and solids, heat, steam, evaporation, heat of combustion, fuels of various types, friction, work, power and electricity. Numerous theoretical and practical problems are included in all of the above subjects.

Practically all men who take the first year of the course enroll for the second year's work. In addition to these men, many who have not taken the first year work desire to take the second year. Five industrial credits are given for the successful completion of each year of the course. At the end of the term, the college issues a certificate stating that five such credits have been awarded the student. Fifteen credits are required to obtain a Mineral Industries Extension diploma.

The second year course deals with such subjects as gas and liquid flow, meters, heat transfer, gas absorption, chemistry of petroleum, historical geology, structural geology, physical geology, oil fields of the United States, origin of petroleum and natural gas, study of fossils, migration and accumulation of oil and gas, drilling methods, drilling equipment, casing packers, cementing, shooting of wells, well logs, permeability, open flow, gas-air lift, pumping, water flooding, well spacing, repressuring, emulsions, storage of petroleum, appraisal, transportation of petroleum, composition of natural gas, measurement and regulation of gas flow, compression of gas and transmission of gas.

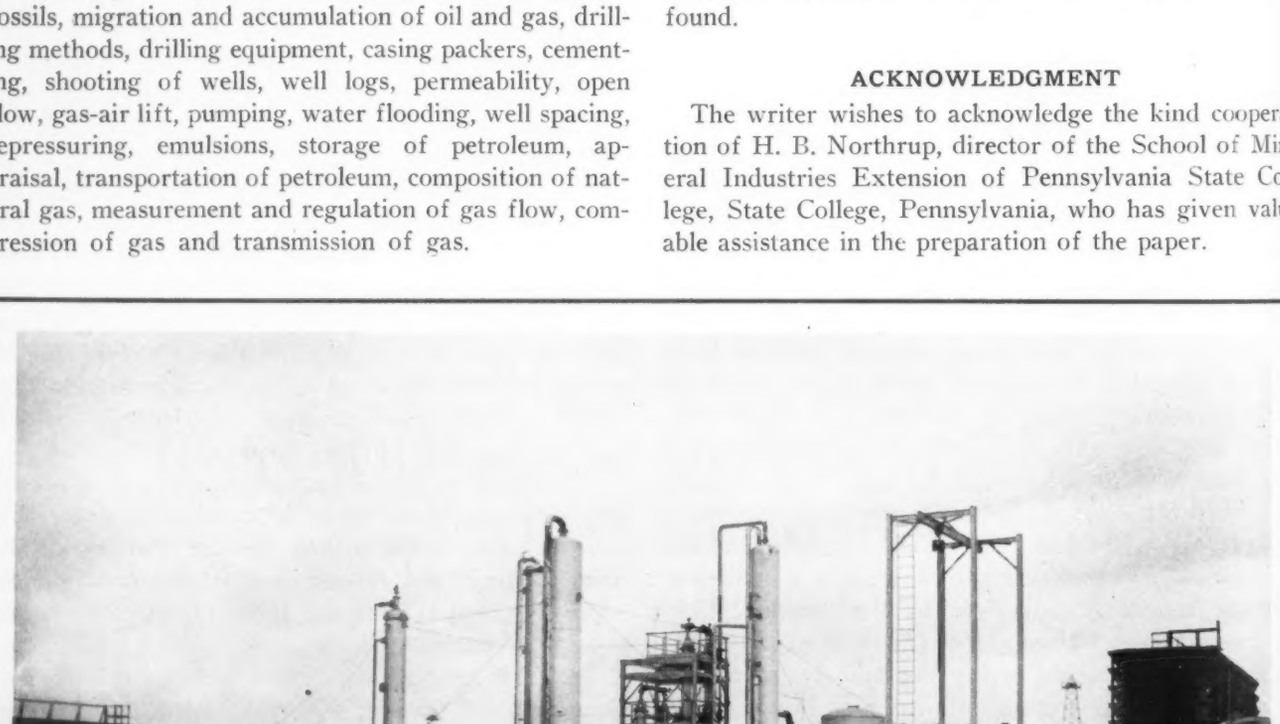
During the second year of the course at Oil City, a number of engineers who are associated with production, oil transportation and oil equipment companies have generously cooperated by lecturing to the class on subjects related to oil and gas production. These lectures were interesting, practical and stimulated considerable discussion.

The third year has not yet been taught at Oil City or elsewhere, but it is planned to teach this part of the course which is petroleum refining during the 1934-35 term. Among the subjects which it is expected to take up are: types of crude, physical properties of crude oils, distillation, design of equipment, refining by chemical methods, refining with clay, flow sheets of plant operations, dewaxing, solvent process, cracking, hydrogenation, refinery products, specifications and tests, stabilization and refinery planning. In natural gas, the subjects to be discussed are composition and analysis, properties, methods of extraction, gathering lines and compressors, helium, carbon black, carbon dioxide and economics.

In the second and third years of the course, references are given indicating where more detailed and additional information on the various subjects may be found.

ACKNOWLEDGMENT

The writer wishes to acknowledge the kind cooperation of H. B. Northrup, director of the School of Mineral Industries Extension of Pennsylvania State College, State College, Pennsylvania, who has given valuable assistance in the preparation of the paper.



Modern installation of intercoolers, (exchangers) at Raccoon Bend, Austin County, Texas.

Formulas for Designing

Natural Gas Pipe Line Systems

Consisting of Parallel Lines[1]

T. W. JOHNSON[2] and W. B. BERWALD[3]

THE United States Bureau of Mines, in cooperation with the Natural Gas Department of the American Gas Association, has been studying actively for the past several years the flow of natural gas through high-pressure pipe lines.[4] This report deals with that part of the study involving the design of pipe-line systems consisting of lines laid parallel to each other. The lines are referred to as the original line and the parallel line. The paralleling line may or may not extend the entire length of the original line; however, the parallel line is connected at its two ends to the original line.

AS a result of the large expansion of the natural gas industry almost all markets within economic distance from the developed gas fields have at least one pipe line supplying them with natural gas. Small increases in the consumers' demand for natural gas can be met usually by increasing operating pressures, but any marked increase in demand necessitates paralleling sections of the existing systems. It is believed that to a large extent future expansion in the natural gas industry will consist of paralleling the present lines. The several formulas given in this report have been developed to aid in the design of such systems. Curves and tables were prepared from these formulas to simplify the calculations materially and to facilitate determination of the sizes of pipe to be used in paralleling various diameter lines to give the most economical design. The formulas are presented without detailed derivations, as a complete report on the flow of natural gas through pipe lines is being prepared which will contain the derivations of these formulas. Examples included here show the detail of application of the several formulas to problems of design of parallel lines.

The general study of the flow of natural gas through pipe lines was made under the supervision of H. C. Fowler, former acting chief engineer, and R. A. Cattel, chief engineer, Petroleum and Natural Gas Division, Bureau of Mines, and of N. A. C. Smith, supervising engineer, Bureau of Mines Petroleum Experiment Station, Bartlesville, Oklahoma.

The study of the flow of natural gas through pipe lines was made in cooperation with the pipe line flow committee, Natural Gas Department, American Gas Association. The members of this committee are: H. D. Hancock, H. L. Doherty & Company, chairman; G. H. Baird, Cities Service Gas Company; E. F. Schmidt, Lone Star Gas Company; R. W. Hendee, Oklahoma Natural Gas Corporation; E. A. Clark, Columbia Gas Company, Pittsburgh, Pennsylvania; T. R. Weymouth, Columbia Gas & Electric Corporation, New York; and E. L. Rawlins, Bureau of Mines.

Special thanks are due to E. L. Rawlins, Bureau of Mines, for assistance in deriving the formulas and to G. H. Baird, Cities Service Gas Company, for assistance in presentation of the data. The manuscript was reviewed also by H. P. Rue, E. S. Burnett, Gustav Wade, H. C. Miller, C. P. Bowie, and G. B. Shea, of the Bureau of Mines.

FORMULAS FOR PARALLEL LINES

The following formulas for solving problems relating to parallel lines are based on Weymouth's formula for the flow of gas through pipe lines[5].

This formula is,

$$Q = 18.062 \frac{T_o}{P_o} \left[\frac{(P_1^2 - P_2^2)\ d^{16/3}}{G\ T\ L} \right]^{1/2},$$

where,

- Q = volume, cubic feet per hour at temperature and pressure bases of T_o and P_o,
- T_o = temperature base, degrees Fahrenheit, absolute,
- T = temperature of flowing gas, degrees Fahrenheit, absolute,
- P_o = pressure base, pounds per square inch, absolute,
- P_1 = inlet pressure, pounds per square inch, absolute,
- P_2 = outlet pressure, pounds per square inch, absolute,
- d = internal diameter of pipe, inches,
- G = specific gravity of gas (air = 1.00), and
- L = length of pipe, miles.

The following formulas are applicable under the conditions that after a section of the original line (or all it) has been paralleled, the temperature and specific gravity of the

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[1]Reprinted from U. S. Bureau of Mines, Report of Investigations 3241.

[2]Associate natural gas engineer, U. S. Bureau of Mines Petroleum Experiment Station, Bartlesville, Okla.

[3]Associate petroleum engineer, U. S. Bureau of Mines Petroleum Experiment Station, Bartlesville, Okla.

[4]Johnson, T. W., and Berwald, W. B., Flow of Natural Gas Through High-Pressure Transmission Lines: Rept. of Investigation 2942, Bureau of Mines, 1929, 18 pp.

Berwald, W. B., and Johnson, T. W., Factors Influencing Flow of Natural Gas Through High-Pressure Transmission Lines: Rept. of Investigations 3153, Bureau of Mines, 1931, 27 pp.

American Gas Association, Pipe Line Flow Subcommittee report to Main Technical and Research Committee on Investigation of the Flow of Natural Gas in High-Pressure Pipe Lines: Oct. 10, 1932, 420 Lexington Ave., New York.

[5]Weymouth, Thos. R., Problems in Natural Gas Engineering: Trans. Am. Soc. Mech. Engr., Vol. 34, 1912, pp. 185-231; also see references foot note 4.

gas and the pressures at the inlet and outlet ends of the original line are the same as they were before paralleling.

Throughout the report the following notation is used:

$\times$ = portion of length of original line paralleled, expressed decimally,

d = internal diameter of original line, inches,

d_1 = internal diameter of parallel line, inches,

Q = volume of gas flowing through the system before paralleling, cubic feet per hour at base conditions of pressure and temperature, and

Q_1 = volume of gas flowing through the system after paralleling, cubic feet per hour at base conditions of pressure and temperature.

The following formula is used to determine the portion of the entire length of line of a given diameter that must be paralleled with the same or a different diameter of pipe to increase the volume of the desired amount.

$$\times = \frac{\left[\left(\frac{Q}{Q_1}\right)^2 - 1\right]}{\left(\left\{\frac{1}{\left[1+\left(\frac{d_1}{d}\right)^{8/3}\right]^2}\right\} - 1\right)} \qquad \text{.....(1).}$$

Equation (1) may be rearranged to give an equation for the volume flowing through a system for any per centage of length of line paralleled with any diameter pipe.

$$Q_1 = \frac{Q}{\left[\times\left(\left\{\frac{1}{\left[1+\left(\frac{d_1}{d}\right)^{8/3}\right]^2}\right\} - 1\right) + 1\right]^{1/2}} \qquad \text{....(2).}$$

Equation (1) may be rearranged also to give an expression for the diameter of the paralleling line that will be required to increase the flow of gas a given amount for a given portion of line paralleled.

$$\frac{d_1}{d} = \left(\left\{\frac{\times}{\left[\left(\frac{Q}{Q_1}\right)^2 - 1 + \times\right]}\right\}^{1/2} - 1\right)^{3/8} \qquad \text{.....(3.)}$$

When the value of $\times$ is 1, or, in other words, when the entire length of the original line has been paralleled, the following relationship may be written.

$$\frac{Q_1}{Q} = \left[1 + \left(\frac{d_1}{d}\right)^{8/3}\right] \qquad \text{.....(4.)}$$

That is, when the entire length of the line has been paralleled, the ratio of the volume after paralleling to the volume before paralleling is equal to 1 plus the eight-thirds power of the ratio of the diameter of the parallel line to the diameter of the original line.

When the diameters of the original and parallel line are the same, equations (1) and (2) simplify to,

$$\times = \frac{4}{3}\left[1 - \left(\frac{Q}{Q_1}\right)^2\right] \qquad \text{.....(5.)}$$

and,

$$\frac{Q_1}{Q} = \frac{2}{\left(4 - 3\times\right)^{1/2}} \qquad \text{.....(6.)}$$

TABLE 1

Percentage of length of original line that must be paralleled to give various percentage increases in delivery.

Increase in Delivery, percent	Values of ratio $\frac{d_1}{d}$																	
	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	M
1	12.8	7.8	5.4	4.1	3.4	2.9	2.6	2.4	2.3	2.2	2.2	2.1	2.1	2.0	2.0	2.0	2.0	1.97
2	25.3	15.3	10.6	8.1	6.6	5.7	5.2	4.8	4.5	4.4	4.2	4.1	4.1	4.0	4.0	4.0	4.0	3.88
3	37.5	22.6	15.7	12.0	9.8	8.5	7.7	7.1	6.7	6.5	6.3	6.1	6.0	6.0	5.9	5.9	5.8	5.74
4	49.3	29.8	20.6	15.7	12.9	11.2	10.1	9.3	8.8	8.5	8.2	8.1	7.9	7.8	7.8	7.7	7.7	7.55
5	60.6	36.6	25.4	19.4	15.9	13.8	12.4	11.5	10.9	10.4	10.1	9.9	9.8	9.7	9.6	9.5	9.5	9.29
7	82.6	49.9	34.5	26.4	21.6	18.7	16.9	15.6	14.8	14.2	13.8	13.5	13.3	13.2	13.0	13.0	12.9	12.65
10	.....	68.4	47.4	36.2	29.7	25.7	23.1	21.4	20.3	19.5	18.9	18.5	18.3	18.0	17.9	17.8	17.7	17.35
15	.....	96.1	66.6	50.8	41.7	36.1	32.5	30.1	28.5	27.4	26.6	26.1	25.6	25.3	25.1	25.0	24.8	24.38
20	.....	.....	83.5	63.7	52.3	45.2	40.7	37.8	35.7	34.3	33.4	32.7	32.1	31.8	31.5	31.3	31.1	30.56
30	.....	.....	.....	85.1	69.8	60.5	54.4	50.5	47.8	45.9	44.6	43.6	42.9	42.5	42.1	41.8	41.6	40.83
40	.....	.....	.....	.....	83.8	72.5	65.3	60.5	57.3	55.0	53.5	52.3	51.5	50.9	50.5	50.2	49.9	48.98
50	.....	.....	.....	.....	95.0	82.3	74.1	68.6	65.0	62.4	60.6	59.4	58.4	57.8	57.3	56.9	56.6	55.55
60	.....	.....	.....	.....	.....	90.2	81.3	75.3	71.3	68.5	66.5	65.1	64.1	63.4	62.8	62.4	62.1	60.94
70	.....	.....	.....	.....	.....	96.8	87.2	80.8	76.5	73.5	71.4	69.9	68.8	68.0	67.4	67.0	66.6	65.40
80	.....	.....	.....	.....	.....	.....	92.2	85.4	80.9	77.7	75.5	73.9	72.7	71.9	71.3	70.8	70.4	69.13
90	.....	.....	.....	.....	.....	.....	96.4	89.3	84.6	81.3	78.9	77.3	76.1	75.2	74.5	74.0	73.7	72.30
100	.....	.....	.....	.....	.....	.....	100.0	92.7	87.7	84.3	81.9	80.1	78.9	78.0	77.3	76.8	76.4	75.00
120	.....	.....	.....	.....	.....	.....	.....	98.0	92.8	89.2	86.6	84.8	83.5	82.5	81.8	81.2	80.8	79.34
140	.....	.....	.....	.....	.....	.....	.....	.....	96.7	92.9	90.2	88.3	86.9	85.9	85.2	84.6	84.2	82.64
160	.....	.....	.....	.....	.....	.....	.....	.....	99.7	95.8	93.0	91.0	89.6	88.6	87.8	87.3	86.8	85.21
180	.....	.....	.....	.....	.....	.....	.....	.....	.....	98.1	95.2	93.2	91.8	90.7	89.9	89.3	88.9	87.25
200	.....	.....	.....	.....	.....	.....	.....	.....	.....	99.9	97.0	95.0	93.5	92.4	91.6	91.0	90.6	88.89
250	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	98.1	96.6	95.5	94.7	94.0	93.6	91.84
300	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	98.6	97.5	96.6	96.0	95.5	93.75
350	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	100.0	98.8	98.0	97.3	96.9	95.06
400	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	99.8	98.9	98.3	97.8	96.00
500	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	99.6	99.1	97.22
600	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	99.8	97.96
A	8.7	15.8	25.6	38.6	55.2	75.5	100.0	128.9	162.6	201.3	245.3	294.8	350.2	411.7	479.4	553.8	635.0	.....

d=internal diameter of original line, ins.; d_1=internal diameter of parallel line, ins.

M=minimum percentage of length of original line that must be paralleled for given percentage increases in delivery, (at which the value of d_1/d is infinitely large).

A=percentage increase in delivery when entire length of original line has been paralleled, for various d_1/d ratios.

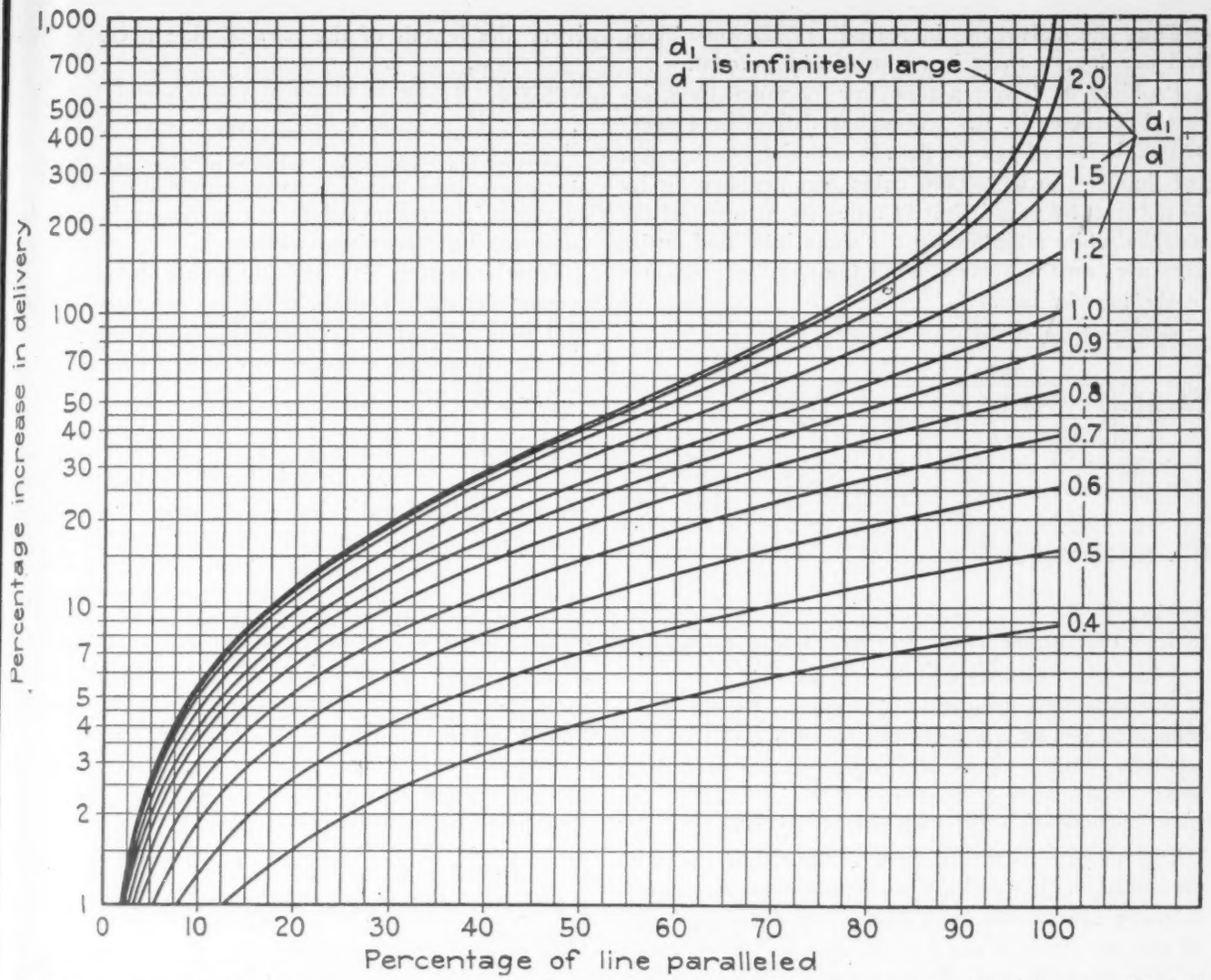


FIGURE 1—Relationship between percentage increase in the delivery and percentage of the original line paralleled for different values of $\frac{d_1}{d}$

Note d_1=internal diameter of parallel line; d internal diameter of original line.

EXAMPLES SHOWING USE OF FORMULAS

The following examples are given primarily to show application of equations 1, 2, and 3.

Problem 1: Given a pipe line 75 miles long, internal diameter (I.D.) 19.4 inches, delivering 40,000,000 cubic feet of gas per day. It is desired to increase the delivery to 50,000,000 cubic feet per day by paralleling a section of the line with 17.5-inch (I.D.) pipe while maintaining the same inlet and outlet pressures on the system. Find the length of the original line that must be paralleled.

Substituting in equation (1),

$$X=\frac{\left(\frac{40{,}000{,}000}{50{,}000{,}000}\right)^2-1}{\left\{\frac{1}{\left[1+\left(\frac{17.5}{19.4}\right)^{8/3}\right]^2}\right\}-1}=\frac{(0.8)^2-1}{\left\{\frac{1}{\left[1+0.7597\right]^2}\right\}-1}$$

$$X=\frac{-0.36}{0.3229-1.000}=0.532$$

Thus, it is necessary to parallel 53.2 percent, or 39.9 miles of the original 75-mile line, to increase the delivery from 40,000,000 to 50,000,000 cubic feet, using 17.5-inch pipe.

Problem 2: Given a pipe line 50 miles long, internal diameter (I. D.) 12.25 inches, delivering 25,000,000 cubic feet of gas per day. If 20 miles of the length is paralleled with 15.5-inch I. D. pipe and the same inlet and outlet pressures are maintained on the system, find the delivery from the system after the section is paralleled.

Substituting in equation (2),

$$Q_1=\frac{25{,}000{,}000}{\left[0.4\left(\left\{\frac{1}{\left[1+\left(\frac{15.5}{12.25}\right)^{8/3}\right]^2}\right\}-1\right)+1\right]}{}^{1/2}=$$

$$\frac{25{,}000{,}000}{\left[0.4\left\{0.1212-1.0\right\}+1\right]}{}^{1/2}$$

$$Q_1=\frac{25{,}000{,}000}{(-0.3515+1.0)^{1/2}}=31{,}044{,}000 \text{ cubic feet.}$$

Thus the delivery is increased to 31,044,000 cubic feet per day, or there is a gain of 24.2 percent.

Problem 3: Given a pipe line 70 miles long, internal diameter (I. D.) 19.5 inches, delivering 45,000,000 cubic feet of gas per day. It is desired to increase the delivery to 63,000,000 cubic feet per day, or by 40 percent, by paralleling 42 miles (60 percent of the length) while maintaining the same inlet and outlet pressures on the system. Find the required diameter of the parallel line.

Substituting in equation (3),

$$\frac{d_1}{d} = \left(\left\{\frac{0.6}{\left[\left(\frac{45{,}000{,}000}{63{,}000{,}000}\right)^2 - 1.0 + 0.6\right]}\right\}^{1/2} - 1\right)^{3/8} =$$

$$\left(\left\{\frac{0.6}{0.5102 - 1.0 + 0.6}\right\}^{1/2} - 1\right)^{3/8},$$

$$\frac{d_1}{d} = (2.3335 - 1.0)^{3/8} = 1.114.$$

From which,

$d_1 = 19.5\ (1.114) = 21.7$ inches, internal diameter of the parallel line.

In the actual design of the line a 22-inch O. D. pipe with a wall thick enough to withstand the line pressure with a reasonable safety factor would be used.

DESIGN OF PARALLEL LINES

The percentages of length of line that must be paralleled to give various percentage increases in gas delivery are shown in Table 1 for different ratios of the diameter of the parallel line to the diameter of the original line. The curves in Figure 1 are plotted from these data and show the nature of the relationship expressed by equations (1), (2), and (3). Some interesting factors and comparisons pertaining to the design of parallel systems are brought out by the equations and by the curves in Figure 1.

The preceding formula for calculating problems in the design of parallel lines eliminate the numerous computations of the "trail-and-error" methods commonly used. Furthermore, a table or a series of curves similar to those in Figure 1 (based on the equations presented in this report) will serve the purpose almost as well as calculations made by the formulas and will reduce materially the time required to design parallel lines. For example, in problem 3 the computed internal diameter of the parallel line is a size not regularly manufactured, and in practice a 22-inch outside-diameter (O.D.) pipe of sufficient wall thickness would be selected; another calculation must then be made, using equation (1) with the correct internal diameter of the 22-inch pipe to determine the actual length of the parallel line. The number of calculations in problems of this type would be materially reduced by the use of the curves in Figure 1. Another advantage in the use of such a series of curves is that for any immediate increase in gas delivery the length of the parallel line necessary for different $\frac{d_1}{d}$ ratios is obtained readily, and from the $\frac{d_1}{d}$ curves the additional length of the parallel line necessary for estimated future increases in gas demand can be determined with ease.

From equation (3) the minimum portion (expressed decimally) of the length of the original line that must be paralleled for any desired increase in volume equals the arithmetical value of the quantity

$$\left[\left(\frac{Q}{Q_1}\right)^2 - 1\right],$$

and for this condition the diameter of the parallel line is infinitely large. The column of figures under letter M in Table 1 and the curve in Figure 1 for a ratio of $\frac{d_1}{d}$ infinitely large give the minimum percentage of the length that must be parallel to obtain specific increases in delivery; however, for this condition the diameter of the parallel line is infinitely large. In other words, for real conditions the percentage of the length of the original line that must be paralleled by another line for a specific increase in delivery is greater than the value given under M in Table 1 or by the curve in Figure 1 for a $\frac{d_1}{d}$ ratio infinitely large.

The figures at the bottom of Table 1 following A are the percentage increases in delivery attained by paralleling the entire length of a line for different ratios of internal diameter of parallel line (d_1) to internal diameter of original line (d). Obviously for a $\frac{d_1}{d}$ ratio of 1 (parallel line same diameter pipe as original line) the delivery is increased 100 percent when the entire length has been paralleled. This same $\frac{d_1}{d}$ ratio requires paralleling of 74.1 percent of the length of the line to increase the delivery of gas by only 50 percent.

ECONOMICS OF PARALLEL-LINE SYSTEMS

A group of curves similar to those in Figure 1 illustrate the economic advantages of certain types of design in parallel pipe lines. The following discussion and examples bring out some of the factors to be considered.

For the small values of $\frac{d_1}{d}$ (ratio of diameter of parallel line to original line), an increase in the value of $\frac{d_1}{d}$ reduces materially the length of the parallel line

TABLE 2

Costs of increasing the gas delivery by using different diameter parallel lines. (Table based on original line 100 miles long and 15.432 inches I.D. pipe).

Diameter of parallel line, inches		Cost of line per mile	$\frac{d_1}{d}$	For 20 percent increase		For 50 percent increase	
External	Internal			Length of Parallel line, Miles	Cost of Parallel Line	Length of Parallel line, Miles	Cost of Parallel Line
22.000	21.250	$30,000	1.377	33.56	$1,006,800	61.00	$1,830,000
20.000	19.378	25,000	1.256	34.90	872,500	63.45	1,586,200
16.000	15.432	20,000	1.000	40.75	815,000	74.08	1,481,600
12.750	12.188	15,000	.79	53.21	798,200	96.74	1,451,100
10.750	10.250	12,000	.664	69.53	834,400	.....	.....

required for any desired increase in delivery. However, for increasing values of $\frac{d_1}{d}$ the amount of change in the length of the parallel line, with change in the $\frac{d_1}{d}$ ratio, decreases. For instance, to increase the delivery 10 percent (see Table 1) it is necessary to parallel a 10-inch internal diameter (I. D.) line for 47.4 percent of its length using 6-inch I. D. pipe ($\frac{d_1}{d} = 0.6$), 29.7 percent of its length using 8-inch I. D. pipe ($\frac{d_1}{d} = 0.8$), 18.9 percent of its length using 14-inch I. D. pipe ($\frac{d_1}{d} = 1.4$), and for 16-inch I. D. pipe ($\frac{d_1}{d} = 1.6$) the percentage of line parallel decreases to only 18.3; for still larger values of the ratio $\frac{d_1}{d}$ the percentage of the original line required to be paralleled decreases gradually to a minimum value of 17.35, and for this percentage the diameter of the parallel line is infinitely large. In other words, for a 10 percent increase in delivery of gas a percentage of the length of the original line greater than 17.35 must be paralleled, and if the ratio of the diameter of the parallel line to the diameter of the original line is two it is necessary to parallel 17.7 percent of the length.

The following examples illustrate a method of analysis of the economics of various designs of parallel lines. The costs per mile of different diameter lines employed in the examples are average values and should be used with caution when applied to specific installations. Variations in cost of labor and materials and in topography of the right-of-way preclude any definite cost figures. However, the costs per mile used for different diameter lines are comparable and for the purpose of the following analysis are accurate enough to indicate certain general trends in the economics of the design of parallel lines.

The problem is to determine the cost of increasing the delivery of a pipe line 100 miles long of 15.432 inch I. D. pipe by 20 and 50 percent, using different-diameter parallel lines. Table 2 shows the length of the parallel line required and its cost, using 22-, 20-, 16-, 12.75-, and 10.75-inch pipe.

The general trend (Table 2) is a decrease in cost as smaller-diameter lines (necessitating paralleling more of the entire length of the original line) are used. However, for the 20-percent increase in gas delivery and for the particular cost figures used the cost of the 10.250-inch I. D. parallel line is slightly more than the cost of the project using 12.188- or 15.432-inch I. D. pipe. For the 20-percent increase in delivery the 16-inch line probably would be the best size to use, since its cost is considerably less than that of the 22- or 20-inch lines and about the same as that of the 12.75- or 10.75-inch line. Furthermore, the 16-inch diameter parallel line has several advantages over the 12.75- and 10.75-inch lines, chiefly in that the shorter length of the 16-inch line that would be required, compared to the length of either of the two smaller sizes, allows more freedom in extending the parallel line to take care of future increases in gas demand. The shorter length of line also has the advantage of lower maintenance expense.

From Table 2 the cost of the 50-percent increase in gas delivery, using the same diameter parallel lines, is proportionately much less than the cost of 20 percent increase in delivery. To illustrate, using 22-inch pipe the average cost of each percent increase for the 20 percent increase in delivery is $\frac{1,006,800}{20}$ = $50,340, whereas the cost of each percent for the 50 percent increase in delivery is $\frac{1,830,000}{50}$ = $36,600.

Industrial Codes and the Purchasing Departments

W. R. KUBISTA

Purchasing Agent, Central States Power & Light Corporation

IN examining numerous competitive bids on various materials and equipment, purchasing agents have observed what seems to be, were it not a serious matter, almost a ludicrous uniformity of prices. Once, to our relief, the monotony was broken by a low bid, only to have it withdrawn the next day as an error. Industrial codes have taken remarkable effect.

In parallel with this, market analysis, as a purchasing function, appears at this time to be simply a matter of being one jump ahead of constantly rising prices. These increases and changes are so rapid it is often impossible to get accurate quotations. Salesmen use the increasing price theme to pry loose pending orders and usually their predictions come true. Some manufacturers have been accepting 60- and 90-day protection orders in which various terms are offered; some liberal, others not so liberal. Their effect is to stimulate volume purchasing.

These and other exacting demands of manufacturers and jobbers' codes have placed purchasing departments on the spot, so to speak. Not only have they pared down quantity discounts, but also in some cases entirely eliminated them, while the resulting economic conditions are gradually forcing prices upward. Although price is still of first importance, the time for criticism of the price fixing tendencies of industrial codes has not yet arrived, because they have brought considerable business activity out of what appeared to be chaos, and because no one can predict accurately what the results will be. Thus the function of purchasing will now have to include a scope of action that is not exactly new, but rather one that has been perhaps somewhat neglected, viz., scientific purchasing. Whether the equipment and materials are for the power plant, refinery, pipe line or field will make little difference, for purchasing departments, more than ever before, must arm themselves with scientific facts.

There never was a more opportune time nor urgent need for further standardization. When the depression was snapping at our heels, the boss gave orders to use as much as possible of the old stuff lying in the storeroom and over the property. The watchword was to conserve cash and to use old stocks, some of which were perhaps obsolete. But now that a good deal of the old equipment has been used up and buying resumed, the new material requirements can, and should, be carefully studied and considered. A weather eye out for duplication or overlapping of properties of material will show up items on which stock can be reduced and will be a good step toward setting up tentative standards. Not only will buying materials with just the required qualities cut down stocks, but perhaps also revive certain aspects of competitive bidding. And where the material is being used for manufacturing, standardization will, of course, have the further advantage of uniformity of product.

In setting up standards the various facts and scientific information usually bring to light the possibility of substitutes. That is to say, such materials or equipment as will fill the requirements yet ultimately lower the manufacturing costs. The cost of the substitute itself may be either higher or lower than that of the material then being used, and only study of its properties or possible performance will reveal to some degree the effect on final costs. When it is practical to do so, an experimental trial will usually provide the greatest enlightenment.

Free consultation and cooperation between the operating and purchasing departments is the next logical step toward standardization. It almost goes without saying that no one knows the characteristics and requirements better than the operating men themselves. Even the laborer or operator can contribute important evidence and information that should not be overlooked. As the data are gradually assembled and tentative standards, acceptable to the operating departments, are set up, the purchasing division acquires a foundation on which to carry on buying scientifically with respect to quality and properties. If substitutes are discovered the operating department can cooperate by making studies and tests and by submitting its recommendations.

The actual trial or introduction of substitutes and new materials and equipment presents further problems. Among the many things to be considered are changes in operation and routine as well as the possibility of delays and contingencies, all of which may show the new at disadvantage. Personal prejudice is another difficulty encountered during the introduction

of substitutes. It has been the writer's experience to have a material of apparently superior quality fail to produce the expected results in actual operation, because of the prejudice of the employes using it. To resist change appears to be human nature. The time-tried old standby with which they are familiar is preferred, and they will often deliberately misuse a new thing as if to prove its inferiority. Such an attitude can usually be overcome with patience and by supplying tactfully those concerned with full information regarding the advantages and features of the new product. That is to say, they must be won over.

A convenient method of checking up and gathering information on various kinds of equipment with respect to performance is a form of equipment failure report, reproduced herein. It is often used jointly by operating and purchasing departments, and copies accompany requisitions for replacements or new equipment. Such reports may be made more or less elaborate, and properly used will supply pertinent facts concerning equipment that has failed in service. They also furnish a systematic check on conditions causing equipment failures, thereby making it possible to direct efforts toward correcting the condition or using more suitable equipment, as the case may be.

Ultimately, complete information leads to written specifications according to which purchases can be made. Since they have to be clear and concise, it follows that the more complete and accurate the data to work with, the better the specifications. Many depend to a great extent on specifications drawn by the trade societies and government bureaus, but some find them wanting or too generalized to be of any great value. They can, nevertheless, be used as a guide in setting up more suitable ones. Performance, is of course, the most desirable basis of specifications, but it is also the most difficult to apply. But here, again, provided with complete information, performance can be used as a basis with greater ease and certainty. Where performance cannot be used there is the usual method of specifying chemical or physical properties, or when that is impractical, supplying approved samples. However, the basis of performance is the most desirable, because it is less liable to confine manufacturers and suppliers to certain raw materials or laboratory tests of doubtful value.

In conclusion, it seems possible that with definite or even tentative standards to follow, and whenever possible, specifications, the problem of code price fixing can, to a certain degree, be circumvented. Price competition at this time may not be affected to any great extent, but in any event the materials bought will have only those qualities needed and the suppliers will still have enough latitude to furnish something better, if they can, for the same price. Thus, if codes tend to eliminate price competition, purchasers can at least look forward to greater competition in quality.

EQUIPMENT FAILURE REPORT

(For Equipment other than Transformers and Arrestors)

Town_____ State_____ District_____

Name Plate Data of Equipment_____
(Copy data as given by manufacturer, on the Name Plate)

Description of Equipment_____
(Tell how it is used and the condition under which it is operated)

Cause of Failure_____
(Tell what happened—load carried—protection now provided and all factors having any bearing on the failure)

Has Equipment been replaced?_____

Give Name Plate data of Equipment substituted_____

Can equipment be repaired, or should new equipment be ordered?_____

How old is equipment that failed?

Would a different type of equipment better fit the requirements, describe how?_____

Has a system of regular inspection been followed?_____

When was an inspection last made?_____

If to be replaced attach requisition giving full description of equipment so no mistake will be made in ordering.

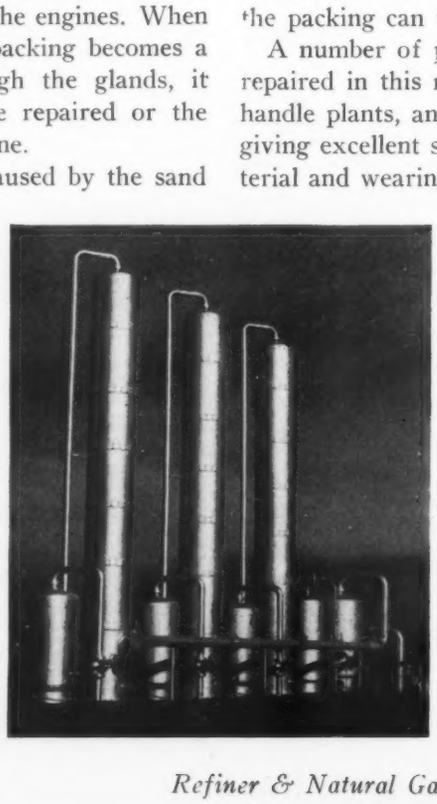
In case of damage to larger equipment notify office immediately.

Building UP Worn Piston Rods

AFTER gas engines have been operated in recovery plants used in extracting gasoline from gas over a considerable length of time, regardless of the manufacturer's care in designing and building, the rods attached to the power and compressor pistons become worn. Wear is accelerated by a number of causes; packing glands adjusted with too much compression, improper alignment of guides and crossheads, insufficient lubrication and, in the case of engines operated in the Texas Panhandle, the accumulation of abrasive sand and particles of soil in the packing. Rods attached to power pistons wear more rapidly than those attached to compressor pistons because of the alternate cooling and heating during the reciprocating movement of the unit while being operated.

Sand in Texas Panhandle causes more wear than in other sections of the country where oil field equipment is being used, because of the extremely high winds which stir up the sandy soil and carry it through buildings and deposit it upon everything, either moving or standing still. It is through no fault or carelessness of the employes operating power equipment, that this occurs, but through the inability of construction crews to build dust proof buildings around the engines. When the machines become so worn that packing becomes a difficult job and gases blow through the glands, it becomes imperative that the part be repaired or the worn member replaced with a new one.

Because of the rapidity of wear caused by the sand filtering through the buildings and being deposited upon the rods of the compressors and power cylinders causing them to wear to such an extent that they cannot be packed successfully, the member is removed with its piston attached and taken to the plant shop and repaired. This is accomplished by welding. Sufficient metal of approximately the same character and composition as the original metal in the rod is applied in consecutive layers with the electric torch to bring the outside diameter of the rod to a size considerably larger than the original. When this has been accomplished to the specification laid out by the machinist who turns the rod down after it has been built up, the assembled rod and piston is taken to the machine shop and placed in a lathe.



No predetermined amount of metal in welding rods can be approximated for each and every job turned out by the welder because of the uneven wearing of the different rods. No two members wear exactly alike, and the only method of arriving at the exact amount of metal which will be required to bring the worn rod to the proper size for machining, is to apply layer upon layer until a sufficient amount of metal has been applied to justify turning.

Considerably more than enough metal to bring the rod to the exact size as when new is applied, to give the machinist enough stock upon which to apply his cutting tool, because if there is a slight roughness near the correct diameter, he may eliminate the flaw by removing an additional few thousandths of an inch more metal and secure a smooth surface upon which the packing can work successfully.

A number of power and compressor rods have been repaired in this manner in Skelly Oil Company's Panhandle plants, and each of the built up jobs have been giving excellent satisfaction, both as to strength of material and wearing qualities at the point of contact with the packing. The cost of these repairs will vary as to the locality and the accessibility of satisfactory shops.

The policy of laying on sufficient metal to bring the worn part to a much larger diameter than it was when new is followed because of the grain of the applied metal, and because if there is a slight out of alignment of the rod, it can be turned straight as well as being brought down to required diameter.

WHAT USED TO BE WEEKS IS NOW YEARS

In a certain cracking plant, high temperatures, exceptionally corrosive gas oil and pressure drops of over 500 pounds used to "eat up" valves in a few weeks.

During 1930, a systematic search was made for valves that could stand this destructive condition. It led to the installation of Chapman Chrome Tungsten Steel Valves . . . and where the life of valves was but a few weeks, they now give years of service. For those original Chapman Valves are still in continuous operation and all inspections and tests indicate that they are none the worse for their ordeal.

Your valve requirements may be less strenuous . . . but Chapman is ready with a complete line of gate, globe and check valves and fittings, in all sizes, for pressures of 150 to 1500 pounds and temperatures to 1000° F. Write "Chapman" into your next valve specifications for every Oil Industry service.

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SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstract, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Chemical Composition and Reactions

Isolation of Mesitylene, Pseudocumene and Hemimellitene from an Oklahoma Petroleum. B. J. MAIR AND S. T. SCHICKTANZ. *Bur. Stand. J. Res.* **11** (1933) pp. 665-679.

An Oklahoma petroleum, after preliminary refinery distillation, was fractionated closely for the separation of the fraction boiling from 118-130°C. This fraction was extracted with liquid sulphur dioxide at —35° to —50°C., and the miscible portion further extracted with liquid sulphur dioxide after admixture with petroleum ether. The extract was finally crystallized from dimethyl ether. Three hydro-carbons were thus isolated in pure condition. It was thus found that this crude oil contained 0.2% of pseudocumene, 0.6% of hemimellitene, and 0.2% of mesitylene. It was considered as probable, however, that more mesitylene could be obtained from lower boiling fractions of the crude.

Spectral Differentiation of Pure Hydrocarbons. U. LIDDEL AND C. KASPER. *Bur. Stand. J. Res.*, **11** (1933) pp. 599-618.

The near infra-red absorption spectra of a number of pure hydrocarbons were determined. It was thought that by this method information might be had regarding the structure of organic molecules where chemical methods are difficult. The apparatus used in described. Thirty-six hydrocarbons were studied. The specific absorption indices were plotted against wave numbers. It was found that several characteristics of the absorption bands were intimately connected with the structure of the molecule. Thus the positions of certain maxima were connected with the presence of primary, secondary, or tertiary linkages. Also aliphatic and aromatic compounds could be distinguished.

Fundamental Physical Data

The Liquid-Vapor Equilibria of Mixtures of Aromatic and Non-Aromatic Hydrocarbons. I. The Liquid-Vapor Equilibria of Mixtures of Benzene, Toluene and Non-Aromatic Hydrocarbons. MASAKICHI MIZUTA. *J. Soc. Chem. Ind., Japan* **37** (1934) Suppl. binding, pp. 60-1.

Fifty parts of straight-run gasoline, free from aromatic hydrocarbons, and boiling from 50 to 120°C. was mixed with twenty-five parts of benzene and toluene. The resulting solution was fractionated into ten cuts and a residue. These were used for equilibrium distillation and determination of the composition of vapors and liquids in equilibrium. The curve so determined runs closer to the diagonal than for binary mixtures of benzene and toluene. This shows that addition of gasoline hydrocarbons to the binary mixtures decreases the efficiency of separation of benzene from toluene.

Phase Equilibria in Hydrocarbon systems. III. Solubility of a Dry Natural Gas in Crude Oil. W. N. LACEY, B. H. SAGE AND C. E. KIRCHER, JR. *Ind. Eng. Chem.* **26** (1934) pp. 652-4.

Gases dissolved in crude petroleum in underground formations play an important part in the recovery of the oil, through causing a marked lowering of the surface tension and viscosity of the oil, thus favoring better drainage from the capillary pores and greater freedom of movement through the sand channels. The assumption that a simple dissolving process occurs when a gas is brought into equilibrium with a liquid in complex hydrocarbon systems is valid only when the system is far enough below the critical temperature of the solvent and the critical pressure of the mixture and there is no appreciable transfer of the components of the original liquid phase into the gas phase. The solubility of dry natural gas in crude oil at 100°F. is almost directly proportional to the saturation pressure. The ratio of solubility to equilibrium pressure has, in general, a roughly linear relation to the specific gravity of the crude oil. Change in gas composition has a marked effect on solubility, as is shown by the large difference in the solubility of methane and of dry natural gas in the same crude oil. The change in volume of the oil for any definite amount of a given gas dissolved is almost the same for all crude oils studied. The apparent specific gravity of a given dry natural gas dissolved in crude oil at 100°F. is nearly independent of the pressure and of the solvent.

Heats of Fusion of Aromatic Hydrocarbons. F. D. ROSSINI. *Bur. Stand. J. Res.*, **11** (1933) pp. 553-559.

A simple calorimeter apparatus was assembled for the quick and economical measurement, with an accuracy of a few percent, of the heats of fusion of several hydrocarbons for which no data exist. The apparatus comprised a vacuum flask with thermolement. The procedure was to determine the time required for the melting of a given weight of the substance in the flask when the latter was surrounded by dry air, the temperature of which was substantially that of the room. The following heats of fusion in kilogram calories per mole. were obtained: pseudocumene, —44.1°C., 2.75±0.06; hemimellitene, —25.5°C., 2.00±0.05; α mesitylene, —44.8°C. 2.28±0.06; β mesitylene, —51.7°C., 1.91±0.05; o-xylene, —25.3°C., 3.33±0.07; m-xylene, —47.9°C., 2.76±0.05. Hemimellitent was found to have two transitions below the freezing point with the following heats of transition: γ—β, —58±2°C., 0.28±0.04, β—α, —46±1°C., 0.36±0.04.

The Relation Between the Temperature Coefficient of Velocity and the Association of High-Molecular Liquids. BUNNOSUKE YAMAGUCHI. *Rept. Aeronautical Research Inst. Tokyo Imp. Univ.* **8** (1934) pp. 229-52.

The association viscosity was calculated from viscosity measurements of benzine solutions of several high molecular weight liquids and the use of Staudinger's equation for the relation between viscosity and concentration. A linear relationship exists between the temperature coefficient of viscosity and the association viscosity of high molecular weight liquids whether polar or nonpolar. The conclusion that the longer the molecule the less the temperature coefficient of viscosity for liquids of the same viscosity at a given temperature agrees with the work of Sullivan on lubricating oils.

Manufacture: Processes and Plant

Diffusion Coefficients in Gaseous Systems. E. R. GILLILAND. *Ind. Eng. Chem.* **26** (1934) pp. 681-85.

One of the attractive possibilities in the reduction of cost in industry is lowering the element of fixed charges by increasing the capacity of given equipment. The engineer too frequently fails to realize that the limiting factor in capacity is the diffusion of the reacting substances. In this article new data are pre-

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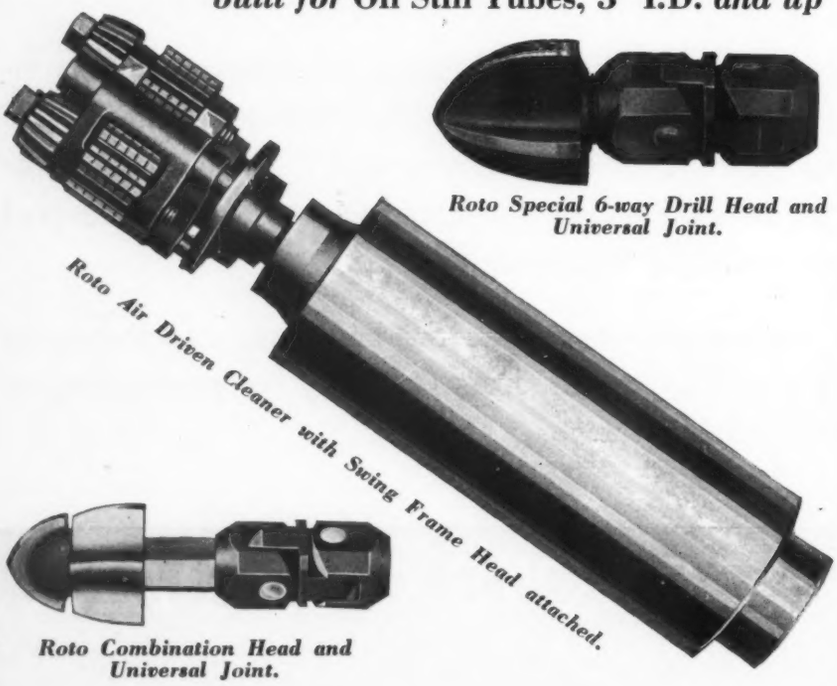

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sented on diffusion coefficients for various organic vapors and for mercury in air at one atmosphere at temperatures from 25.9 to 341°C. Data from the literature on diffusion coefficients for a large number of gaseous systems have been collected and plotted. It is found that the data are better correlated by the groups of the original Maxwell equation than by the Federland modification, and that the larger part of the data can be represented within the accuracy of the experimental methods by the Maxwell equation with an empirical constant. The results are applicable to such operation as the combustion of solid and liquid fuels, the acceleration of gaseous reactions with solid or liquid catalysts, distillation operations of all kinds, selective absorption of gasses by liquids, stripping of volatile components from dilute solutions by steam distillation, the drying of solids and other similar operations.

Developments in Heat Transfer With Organic Compounds. R. L. HEINDEL, JR. *Chem. & Met. Eng.* 41 (1934) pp. 308-12.

Indirect heating has been accomplished by steam, hot gasses, oils and a number of organic compounds and mercury. Saturated steam has a practical and economical upper limit of temperature in the neighborhood of 450°F. If temperatures above 750°F. are to be used, mercury is the logical material. Oils have been used in practical application at temperatures below 600°F. At the present time the most practical heat transfer medium for operation in the range of temperatures from 450 to 750° F. is the eutectic mixture of diphenyloxide and diphenyl. The minimum freezing point is 53.6°F. A similar eutectic mixture is that of diphenyl oxide and naphthalene, having a freezing point of 61°F. The properties of these mixtures are presented and their practical handling is discussed. Application to power generation and to varied uses in the process industry is considered. The heat transfer coefficient from condensing Dowtherm vapors to dry steam has been found to be 45 to 57 B.t.u. per square foot per hour per degree Fahrenheit. The film coefficient on the medium side has been found to be in the range from 230 to 380 B.t.u. per square foot per hour per degree Fahrenheit at velocities from 5 to 9 feet per second.

Mercury Vapor as Applied to Process Industries. C. A. HULSART. *Chem. & Met. Eng.* **41** (1934) pp. 313-16.

The use of mercury vapor as a medium for heat transfer is neither new nor untried. The first commercial applications to process work were made in 1915 in connection with the distillation of beta naphthol and the sulphonation of naphthalene. Since that time 19, or more, mercury units have been built, of which the best known are those of the Sun Oil Company for the distillation of lubricating oils. The advantages of mercury are: high temperature is obtained with a low pressure; mercury is an element and therefore has no tendency to dissociate or form compounds by rearrangement; mercury is not a solvent for, nor does it form an amalgam with steel, therefore heating surfaces are not fouled; mercury solidifies at —38° F., which eliminates freezing; mercury is easily returned to the boiler by gravity because of its high specific gravity; mercury is non-inflammable. The author minimizes the criticism of the use of mercury on account of its poisonous nature and states that mercury vapor, if in sufficient volume to cause serious effects, produces so much discomfort to the person exposed that he has ample warning of its presence. Applications of mercury for heating purposes are described.

Did you know that one Dubbs refiner went back to firing his boilers with coal because he could sell his Dubbscracked fuel oil at a premium?

One did

Probably others have done so, too

Undoubtedly more will do so as buyers come to understand that Dubbscracked fuel oil has more B.t.u. to the barrel than ordinary oil

There is never enough Dubbscracked fuel oil to go round

Nor enough Dubbscracked gasoline

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Chicago, Illinois

Dubbs Cracking Process
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Reports on the Progress of Naphthology. INST. OF PET. TECH. *Jour. Inst. Petroleum Tech.* **20** (1934) pp. 343-452.

This series of papers constitute the annual report of progress in the petroleum and related industries during 1933. The subjects covered are: the cracking art, chemical and physical refining, natural gas and natural gasoline, crude oil, motor spirits and light distillates, gasoline engine and knock testing, kerosene and water white, lubricants and lubrication, gas oils, Diesel fuel and fuel oil, oil engine development and the testing of Diesel fuels, asphalt and road materials. At a somewhat later date these reports are published separately and can be purchased from the Institution of Petroleum Technologists, Aldine House, Bedford Street, London, W. C. 2, England.

The Refining of Petroleum by Means of Active Oxygen and Its Scientific Foundation. J. HERZENBERG. *Erdol u. Teer,* **9** (1933) pp. 436-9, 448-51, 460-3.

The theory and practice of refining for removal of gum-forming components and sulphur compounds is discussed. Various of the unsaturated alipathic and cyclic components separated from narrow boiling fractions from primary tar benzine and brown-coal-gas benzine were identified through the glycols obtained from them. The sulphur compounds in brown-coal benzine and in a Mexican Panuco crude benzine fraction were examined. The thiophanes identified by Maybery in 1906 were isolated and identified by the use of a mercuric chloride complex. Anodic oxidation in acetic or potassic acetate solutions was found to be effective in oxidizing the substances, as was electrolysis in a heterogeneous system comprising the benzine and sulphuric acid and employing the diaphragm and mechanical emulsification. A combination of electrolytic oxidation and pressure hydrogenation is suggested.

Transformer Oil. II. Refining With Dilute Sulphuric Acid. M. BOLTUS-GORUNEANU. *Bul. Chim. Soc. Romana Stiinte,* **35** (1932) pp. 17-19.

It is stated that 60% sulphuric acid is preferable to more concentrated acid for the refining of transformer oil. The formation of tarry deposits in transformers is caused by hydrocarbon components and not by sulphur and nitrogen compounds, as has frequently been thought.

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Products: Properties and Utilization

Motor Fuel Performance. G. G. BROWN. *Proc. 12th Ann. Conv. Nat. Gasoline Assoc.* (1933) p. 64.

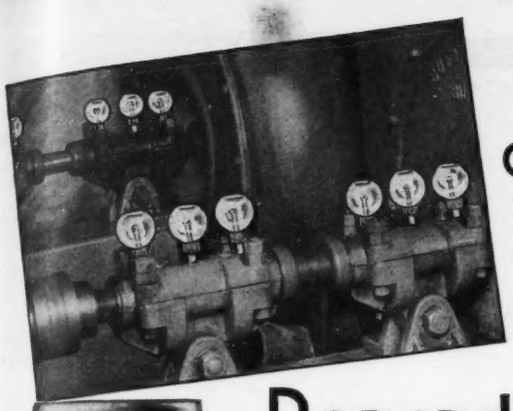
Gravity and end point are recognized as inadequate criteria of effective volatility. A volatility index is desirable, which used in conjunction with octane number would satisfactorily give the value of a fuel from the consumer's standpoint. The difference between 284° F. and the 50% point on the A.S.T.M. distillation curve is taken as the volatility index and appears to be a reasonably satisfactory means for expressing effective volatility. Relative performance at any particular atmospheric temperature for a given fuel may be judged by plotting the A.S.T.M. distillation curve on an appropriate chart. Comparisons are to be made with engine carburetor adjusted for maximum power under normal operating conditions. Data on octane number, torque and volatility index indicate that in the critical range where performance suffers by the use of a lower volatility index or a lower octane number, the two properties are of approximately equal weight.

Present Status of the Vapour Lock Problem. O. C. BRIDGEMAN, H. S. WHITE AND F. B. GARY. *Proc. 12th Ann. Conv. Nat. Gasoline Assoc.* (1933) p. 74.

The conclusion previously reached that high fuel line temperatures are mainly responsible for vapor lock trouble remains unchanged. There has not been great improvement in cars from 1932 to 1933. Over a period of years the vapor handling capacity of fuel systems has improved and has reduced vapor lock trouble, but this has been done at the expense of a marked increase in fuel consumption. Actual determination of the vapor handling capacity of a very large number of cars has permitted the formulation of permissible fuel vapor pressures over a wide range of operating conditions and with fuels of widely different other characteristics. Further work on vapor lock and relation to fuel characteristics is contemplated by the Bureau of Standards.

An Appraisal of the Lead Hazards Associated with the Distribution and Uses of Gasoline Containing Tetraethyl Lead. R. A. KEHOE, F. THAMANN AND J. CHOLAK. *J. Ind. Hgy.* **16** (1934) pp. 100-27.

Considering the evidence obtained in the study of persons exposed to leaded gasoline and its combustion products, it is concluded that there is no reason to fear the existence of a public health from the distribution and use of leaded gasoline. The exposure of the average user



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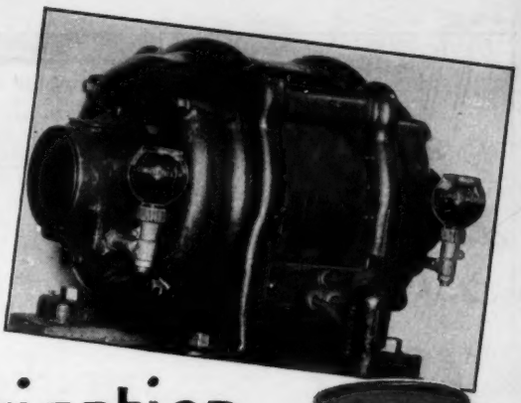
ECONOMY



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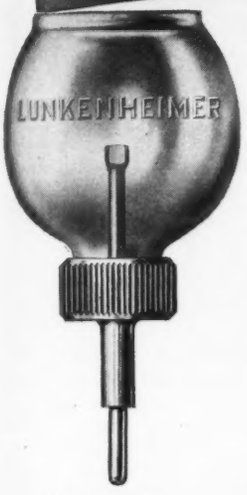

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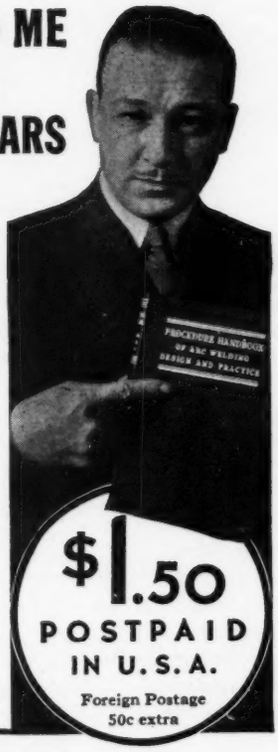

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is far less than that of those persons observed in the study.

Peroxides in Gasoline. Peroxidation in Relation to Gasoline Composition. J. C. MORRELL, C. G. DRYER, C. D. LOWRY AND S. EGLOFF. *Ind. Eng. Chem.* **26** (1934) pp. 655-58.

It has previously been shown that cracked gasoline reacts with oxygen to form peroxide and other products such as gum. To demonstrate to what components this reactivity is to be attributed, two methods of procedure were followed. The properties of the gasoline were determined after removal of conjugated diolefins, and again after elimination of all olefin hydrocarbons. The oxidizability of the number of pure hydrocarbons was studied, using the hydrocarbons singly and blended one with another, and also blended with gasoline. The following conclusions were reached: The reaction of cracked gasoline with oxygen to form peroxide is attributable in part to conjugated diolefin and in part to other olefins. Removal of olefins produces a product that is extremely resistant to oxidation. The tendency of olefins to form peroxide and gum differs widely among members of a series, and with any particular olefin is greatly influenced by concentration. A gasoline may contain a high concentration of olefins and yet be resistant to oxidation. When olefins and diolefins are present together, more peroxide compounds and more gum are formed than when these substances are present singly in the same concentration. Under the conditions employed, the oxidation of paraffin, cyclohexane and aromatic hydrocarbons is zero or negligible.

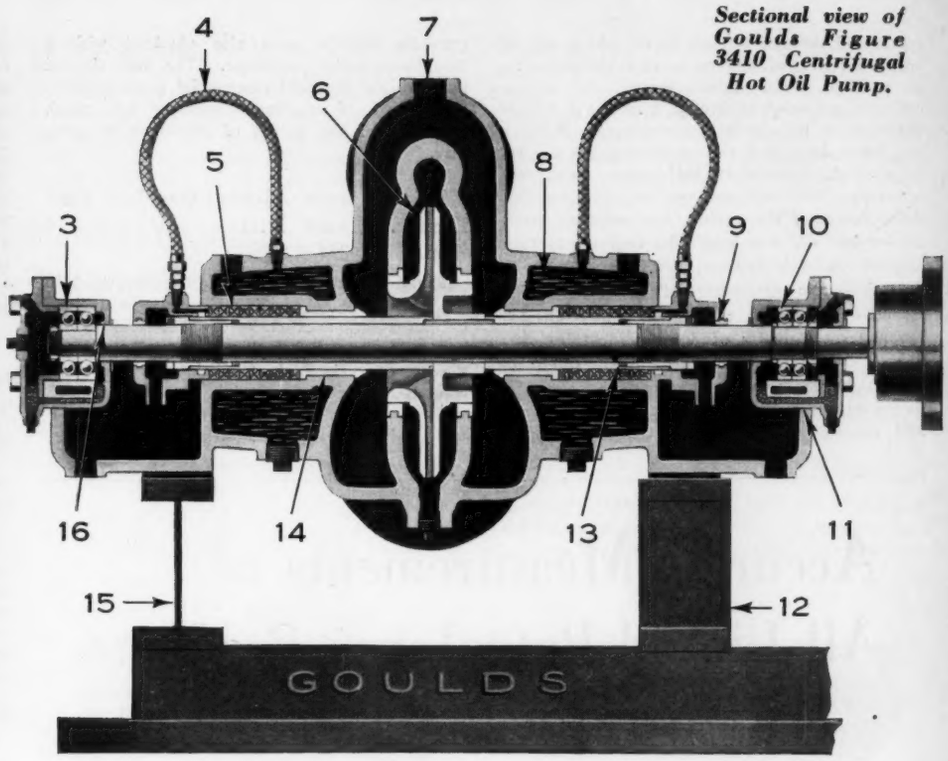
Influence of Temperature on Detonation. P. DUMANOIS. *Ann. des Comb. Liq.* **9** (1934) pp. 143-144.

The authors note that the peroxide theory of detonation has been supported by many observations, and that it has been shown that in a mixture of saturated hydrocarbons and air, at atmospheric pressure, peroxides started to form at 120° to 130° C., and are entirely decomposed at 300° C. They reason, therefore, that it should be possible by raising the mixture temperature rapidly, to pass through the peroxide-forming stage with speed enough to eliminate peroxide formation, and thus to eliminate detonation. Experiments are described in which a C. F. R. engine running at 600 r.p.m. was operated at a jacket temperature of 150° C. using ethylene glycol as a cooling medium. A thermocouple was placed in the combusion chamber to indicate the mean temperature of operation. While the engine was operating in a normal manner without detonation, the compression ratio was quickly increased to give sharp detonation. At a temperature of 340° C. detonation entirely disappeared and the engine ran quietly. This continued with the ignition off. However, the temperature increased until popping back occurred. The phenomenon was capable of repetition and the temperature of 340° C. was definite. At jacket temperatures lower than 150° C. the results could not be obtained.

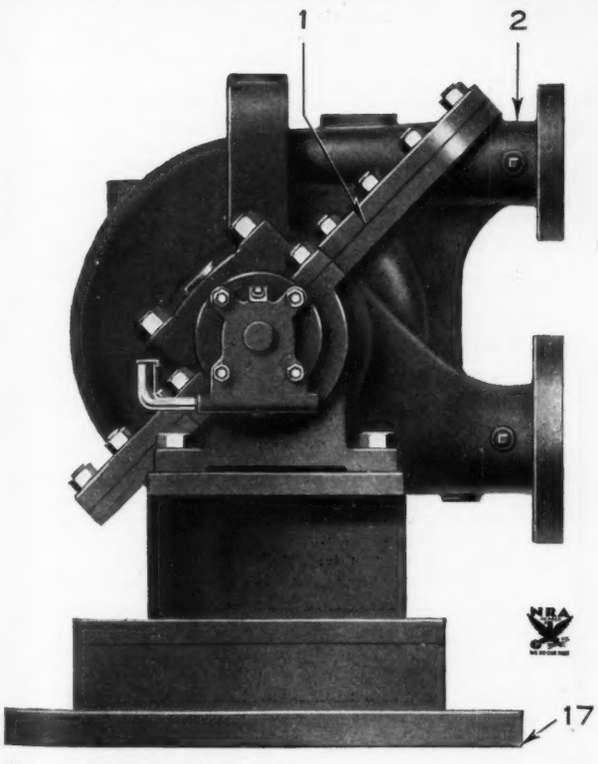
Measurement of Flame Temperature in a Petrol Engine by the Spectral Line-Reversal System. S. S. WATTS AND B. J. LLOYD EVANS. *Engineering,* **137** (1934) p. 362.

The authors introduced a 1% solution of sodium ethylate in alcohol into the gasoline in the proportion of 15 c.c. per gallon. The combustion chamber of the engine was fitted with two quartz windows. Light from an electric

18 Reasons Why



Sectional view of Goulds Figure 3410 Centrifugal Hot Oil Pump.



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11. Large capacity oil reservoirs are water cooled.
12. Rigid Support at coupling end.
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16. Bearing housing sealed against oil leakage and entrance of foreign matter.
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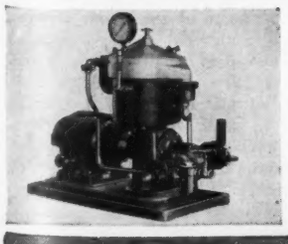

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arc passed through suitable lenses and a pair of adjustable neutral wedges to vary the intensity. A parallel beam passes through the engine cylinder and emerges through a lens that focuses the beam on the slit of a spectroscope. Between the latter lens and the spectroscope a stroboscope disc running at half-engine speed was inserted. The wedges were adjusted so that the reversal of the sodium line occurred while the engine was running. The engine was then stopped and the spectroscope replaced by a monochromatic pyrometer of the disappearing filament type. To obtain a reading on the pyrometer the quartz window and focusing lens nearest the spectroscope were removed and readings taken when engine conditions were steady. Temperatures of over 1200° C. can be observed and repeated to within 15° C. Photographic pressure records were also obtained with a Hopkinson optical indicator. The data showed that using a standard commercial grade gasoline the period of maximum pressure was much shorter than the period of maximum temperature.

Results from Alcohol-Gasoline Fuel Blends. HARRY MILLER. *Agr. Eng.* **14** (1933) pp. 274-6, 278.

The difficulties in lubrication encountered in the use of alcohol-gasoline blends were avoided by the addition of 0.5% of oleic acid to the lubricating oil. Exhaustive block and road tests were made. The highest efficiency was secured from blends of 75% gasoline, 20% ethylalcohol, and 5% higher alcohols. Blends of this character ordinarily separated into two layers at approximately 20° F., but this separation was prevented at temperatures down to —40° F. by the addition of suitable stabilizing agents. Using conditions that caused premium grade gasoline to detonate violently, it was found that no detonation occurred with the alcohol blends. Gasoline-alcohol blends containing 10% of absolute alcohol were intermediate in properties between regular gasoline and premium gasoline. Those blends containing commercial alcohol had better anti-knock properties than those made from absolute alcohol because of the water content.

Properties of Hydrogenated Solvent Naphthas. W. J. SWEENEY AND J. A. TILTON. *Ind. Eng. Chem.* **26** (1934) pp. 693-96.

Recent developments in the field of lacquers and varnishes show a decided trend toward the use of synthetic resins. Many of these resins are soluble only in the more aromatic hydrocarbon solvents. This has created a demand on the petroleum refiner to improve the solvency of his naphtha products. Among the processes for the manufacture of higher solvency petroleum naphthas, the catalytic high-pressure hydrogenation of naphthenic type petroleum fractions has shown decided possibilities. Petroleum fractions such as the extracts obtained from the sulphur dioxide treatment of paraffin cuts for the improvement of the latter in burning quality and cracked gas oils of refractory and aromatic nature, have been converted by high-temperature catalytic hydrogenation to lower boiling point distillates. Fractions of commercial boiling ranges and solvency characteristics can be prepared from these. Data are presented showing the properties of a representative line of such solvents with a wide range of evaporation rates. These data indicate that this line of hydrogenated solvents possess sufficiently high solvency powers for satisfactory use in most synthetic resins, and at the same time offers a wide variety of evaporation rates.

Solvents for Dry Cleaning. ANON. *Chem. Trade J.*, **94** (1934) p. 192.

The comparative merits of petroleum naphthas and chlorohydrocarbons for dry cleaning purposes were discussed at a meeting of the London Section of the Society of Dyers and Colourists. Trichloroethylene and carbon tetrachloride are desirable because of absence of fire risk, and because their solvent action is quicker and more powerful than that of naphtha. Greasy material is removed more thoroughly and non-greasy material spots out more easily. Chlorohydrocarbons do not cause greying or dulling of whites and also they have a clearing action on the color of silks. Odorless cleaning can be guaranteed, and the cost of steam for drying is less than with naphtha. Chlorinated hydrocarbons are three times as expensive as naphtha, but they can compete, and in some instances are less expensive. Solvent recovery is complete; in one plant the loss was only 1.5% of the dry weight of the goods cleaned. On the other hand, naphtha has no action on textiles or dyes, and does not decompose in sunlight or under the action of water or metals, whereas carbon tetrachloride tends to decompose, giving HCl and Phosgene. Trichlorethylene is less toxic than carbon tetrachloride, but produces giddiness and nausea if inhaled. It has some solvent action on dyes, particularly those used for cellulose acetate rayon. Hand-brushing is important in dry cleaning, but the chlorinated hydrocarbons constitute a hazard to health.

Oxidation Products of Lubricating Oils. L. BOISSELET AND C. MOURATOFF. *Ann. des Comb. Liq.*, **9** (1934) pp. 69-76.

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authors conclude that the action of oxygen on oils at the temperature employed in their work, which is about 155° C., is one of oxidation. Asphalt is not formed under their experimental conditions, and asphaltic substances are only formed at elevated temperatures and are caused by polymerization and condensation. Deposits obtained from transformers contain only acids and metallic soaps. These deposits were studied in some detail through fractionation under vacuum of the methyl esters of the organic acids, combustion analyses, boiling points, molecular weights, determination of hydroxyl radical, and acidity and analyses of silver salts of some of the free acids. These data are presented in tabular form. The brownish-yellow deposits from transformers were freed of oil by petroleum ether extraction, and were then treated with dilute nitric acid and ether. Three layers obtained: (1) An aqueous layer containing the metals and water-soluble products, such as formic and acetic acids, saturated cyclic acids and acids containing two atoms of oxygen but not belonging to the fatty series; (2) an ethereal layer of acids; (3) insoluble material, part of which is soluble in chloroform, the remainder being particles of solids. The conclusion from the work was that the isolated acids were cyclic saturated acids having a carbonyl group. Additional oxygen was not present in the form of alcohol, aldehyde, ketone or lactone groups. Oxygen has in all probability entered into the ring structure.

Lubricating Oils Containing Rubber. D. HOLDE. *Petroleum Z.* **30** (1934) No. 2, p. 1.

Lubricating oils containing rubber have not been sold for some time, but are again being manufactured. The rubber content is 1-2%. The products are of stringy character and are considered valuable because they are not entirely removed from gears. The analysis of such products is discussed.

Flow of Petroleum Lubricating Greases. M. H. ARVESON. *Ind. Eng. Chem.* **26** (1934) pp. 628-34.

This is the second in a series of articles on lubricating greases. To the variables previously studied, namely, apparent viscosity and rate of shear, a third, temperature, is added. Petroleum lubricating greases are dispensed and used under varied conditions in which factors determining the flow characteristics are of primary importance. A variety of greases has been studied at 77°, 50°, 25° and 0° F., using the constant shear viscometer. All data on greases containing calcium mixed fatty acid salts have been correlated into one general curve, in which the viscosity of the oil in the grease at the temperature used and the soap factor K, determined primarily by the soap content, and the rate of shear are primary factors determining the apparent viscosity of the grease. A small correction is required for the effect of temperature on the soap factor. A mechanical conception of grease structure and the behavior of grease during flow is presented. That Bingham's equation will not apply to the data is demonstrated.

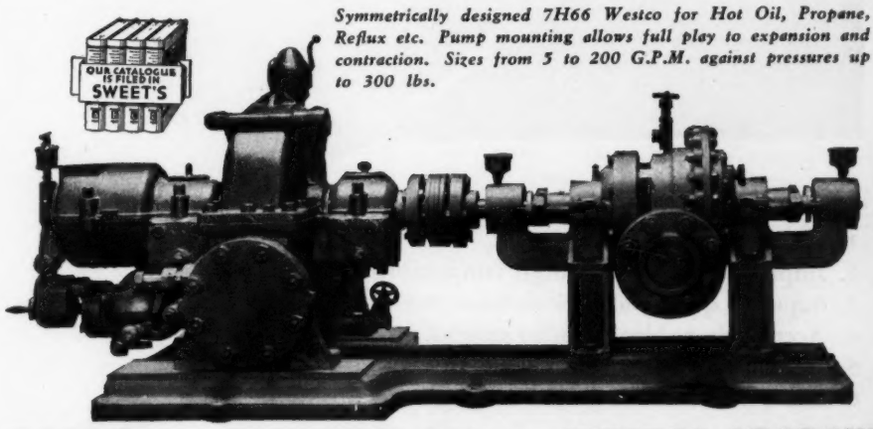
Lubrication of Bearings With Greases. H. VON SCHROETER. *Petr. Z.*, **30** (1934) pp. 1-20.

The properties of greases are described. Kissling's method for determination of consistency is claimed to be the best. The change in consistency resulting from change of temperature, pressure and from mechanical effects are discussed. A white metal bearing was lubricated with five different greases. The result showed that a limit was reached in lubrication in which the excess of lubricating film no longer resisted the mechanical effect. This limiting value depended upon the type of grease, its consistency, and to some extent on the velocity of the moving layer. It was influenced strongly by the arrangement of the lubricating nut. By change in design of the nut it was found possible to increase the load carrying capacity of the layer by 75% using the same quantity of lubricant. The results are presented in the form of curves and tables.

Natural Gas and Natural Gasoline

Comparison of Anti-Knock Characteristics of Vapor Recovery and Natural Gasoline Blends. H. M. TRIMBLE. *Proc. 12th Ann. Conv. Nat. Gasoline Assoc.*, (1933) p. 32.

Vapor-recovery and natural gasolines were prepared having vapor pressures of 14, 18, 22 and 26 pounds. Each of these was blended with three gasolines, giving blends having the same vapor pressure. The blends were analyzed by close fractionation at low temperature. Fuels were tested by conducting them to the carburetor of the engine through chilled lines under pressure. Existent and potential gum was determined. It was concluded that the volatility effects of the two light gasolines were the same except for a slight vapor pressure margin in favor of natural gasoline. Natural gasoline blends were higher in A.P.I. gravity. The octane ratings of the vapor-recovery gasoline blends were higher than those of equivalent natural gasoline blends regardless of the method of testing. Natural gasoline has a higher lead susceptibility than vapor-recovery gasoline.



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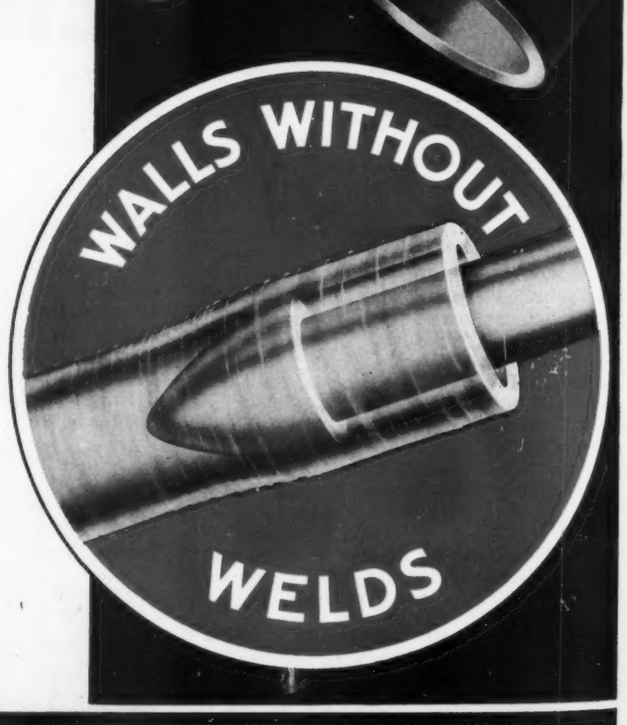

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THE MONTH IN REVIEW

Gasoline Tax Conference In Atlantic City

GOVERNOR A. Harry Moore, of New Jersey, tentatively has accepted an invitation to speak at a banquet to be held in the Hotel Claridge, Atlantic City, New Jersey, on September 13, as one feature of the program of the annual meeting of the North American Gasoline Tax Conference. Governor Moore also has addressed a letter to governors of every state inviting them to attend or to send representatives.

State officials entrusted with the responsibility of collecting annually more than $500,000,000 in gasoline taxes are represented in the conference, of which James L. Duce, of Colorado, is president.

Arrangements for the sessions are being made by the conference council, of which Joseph L. McLaughlin, New Jersey's gasoline tax collector, is chairman, and by the New Jersey State Committee, with Judge Frank G. Driscoll, of Sinclair Refining Company, as chairman.

Every state and every oil company has been asked to send representatives to the conference and to participate in the discussion of gasoline tax collection problems.

New Officers of Society Of Chemical Industry

THE American Section of the Society of Chemical Industry announces the election of the following officers to serve for the year ending June 1, 1935: Chairman, Robert J. Moore; vice chairman, W. D. Turner; secretary, Foster D. Snell, and treasurer, J. W. H. Randall. In addition five new members were elected to the executive committee to take the place of retiring members. Those newly elected are Lincoln T. Work, Wallace P. Cohoe, Albert E. Marshall, James G. Vail and Charles A. Lunn.

Salesmanagers Committee Named

THE Natural Gasoline Association of America, through its board of directors recently announced the personnel of the new salesmanagers committee of the association. A. T. Scherer, Sinclair Prairie Oil & Gas Company, remains as chairman. Ray E. Miller, Hanlon-Buchanan, Inc., Tulsa, formerly secretary for the association, was appointed a member, as was Lew Morgan, Continental Oil Company, Ponca City, and Art Reuther, Shell Petroleum Corporation, St. Louis. The following were re-elected: J. F. Nagles, Skelly Oil Company, Tulsa; S. B. Crooks, Empire Oil & Refining Company, Bartlesville; W. H. Anders, Columbian Gasoline Corporation, Monroe; J. A. LaFortune, Warren Petroleum Company, Tulsa; L. P. Calkins, Phillips Petroleum Company, Bartlesville. Mr. Reuther was elected vice chairman of the committee.

Diamond Jubilee of Oil at Titusville

GOVERNORS PINCHOT, of Pennsylvania, and White, of Ohio; Federal Oil Administrator Harold L. Ickes; President Axtell J. Byles, of the American Petroleum Institute, and Mayor Arthur G. Bellen, of Titusville, are listed as speakers on the tentative program of the Diamond Jubilee of Oil to be celebrated at Titusville, Pa., August 24 to 27. At that time the Drake Well Memorial Park, about the site of this country's first commercial oil well, formally will be dedicated and presented to the State of Pennsylvania by the American Petroleum Institute.

This celebration of the petroleum industry's 75th anniversary will start Friday, August 24, "Oil Region Day," with a sightseeing tour of the Drake Well Memorial Park and other historical sites. The Diamond Jubilee of Oil Exhibition formally will be opened early in the afternoon. At night an historical pageant, "The Story of Oil", will be presented at the fair grounds.

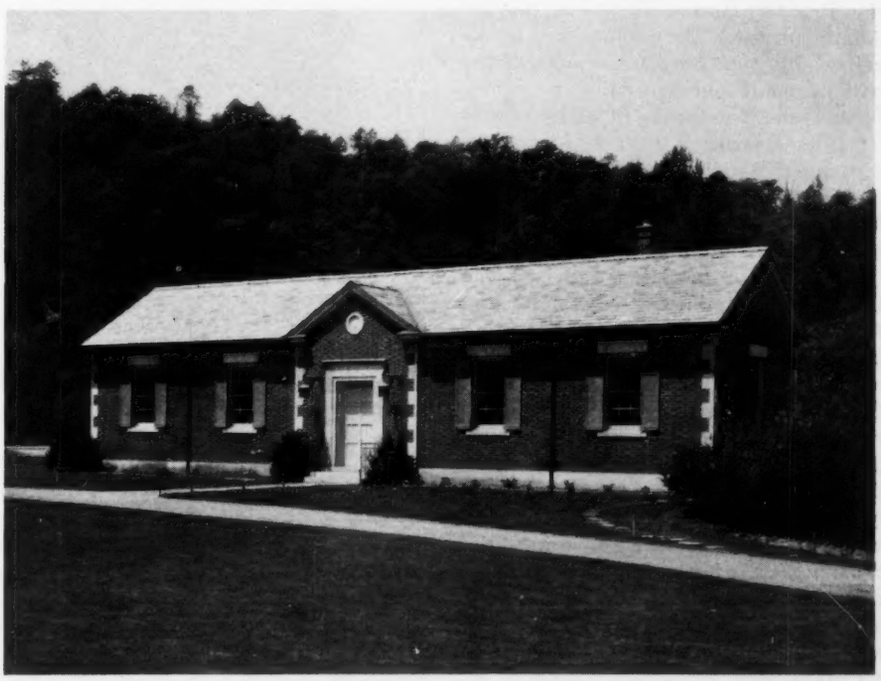
Saturday, August 25, will be "Jubilee Day," with a parade in the afternoon and a pageant at night. There will be band concerts in the park and the Diamond Jubilee Ball in the gymnasium of Colestock High School. Sunday, August 26, is to be "Old Home Day" with special church services, band concerts, and singing.

Monday, August 27, the 75th anniversary of the appearance of oil in the Drake well, will be celebrated as "Drake Day." Dedicatory exercises will be held in the afternoon, and mardi gras, fireworks, and band concents at night.

Labor Policy Board Chairman Resigns

RESIGNATION of Dr. William M. Leiserson, chairman of the Petroleum Labor Policy Board, so that he might return to his chair as professor of economics at Antioch College, was announced July 22. It becomes effective on August 1, 1934.

Dr. Leiserson presented his resignation to Secretary of the Interior Har-



The Drake Memorial Museum at the Drake Well Memorial Park, Titusville, is the only museum in the world devoted exclusively to the preservation of oil field historical data, records and equipment.

old L. Ickes, the Oil Administrator, before Administrator Ickes began his vacation trip to the West. He requested Administrator Ickes to relieve him as of August 1, so that he could return to his professional duties at Antioch College, with which he has been connected since 1925. In accepting appointment to the board last December, Dr. Leiserson said he could serve for only a few months.

Dunlap Made Publicity Director

PENNSYLVANIA Grade Crude Oil Association has announced appointment of Wes. W. Dunlap as publicity director for the organization. Dunlap leaves a similar position at Pennsylvania State College. He succeeds J. F. Moorhead, who resigned recently to accept a position with the Rio Grande Oil Company, Los Angeles. Previous to his connection with State College, Dunlap was on the staffs of several mid-western newspapers, including the Minneapolis Tribune. He has been closely associated with the association sponsored research department at State College.

Natural Gasoline Statistics Requested

PRODUCERS and manufacturers of natural gasoline east of California hereafter will be required to submit monthly reports to the Oil Administration under an order by Secretary of the Interior Harold L. Ickes, the Oil Administrator. The reports will be received by the Bureau of Mines and will be made out according to a new form issued by the Petroleum Administrative Board. The new form calls for more detailed information as to shipments than was required on a form previously used by the Bureau of Mines.

The Bureau of Mines advised the Petroleum Administrative Board and Administrator Ickes that obtaining more detailed reports from manufacturers of natural gasoline would assist in gauging consumer demand for gasoline which is the basis for the allocation of gasoline and crude oil production allowables. Information previously obtained, it was explained, failed to supply sufficient data covering the consumption of natural gasoline elsewhere than at refineries. However, it provided usable figures permitting accurate forecasts that were approximately exact.

Because a large part of the natural gasoline production goes directly to the consumers, the new forms require detailed information concerning distribution direct to the consumer be supplied.

The new form on which the reports will be made are expected to be ready for distribution by the Bureau of Mines between August 1 and August 15.

Patent Litigation

INFRINGEMENT of cracking patents is charged in suits just filed by Universal Oil Products Company against four Mid-Continent refiners. The defendant companies are the Eldorado Refining Company, Eldorado, Kansas; Globe Oil & Refining Company, McPherson, Kansas; Dickey Refining Company, McPherson, Kansas; Kanotex Refining Company, Arkansas City, Kansas.

The defendants are charged with infringing the Dubbs clean circulation patent and the Egloff 2-coil patent. All claims are alleged to be infringed except Claim 6 in the Dubbs patent. These are the two patents which Federal Judge John P. Nields found to be valid and infringed in the suit of Universal Oil Products Company against Root Refining Company.

The Eldorado and the Globe companies are using Winkler-Koch cracking units, the Dickey company a cracking unit of its own design, and the Kanotex a so-called Winkler-Koch unit licensed under the Donnelly patents.

The suits were filed in the Federal District Court at Wichita, Kansas.

Diesel Hand Book

THE Diesel Hand Book is described as a practical book of instruction for engineers and students on modern Diesel engineering, land, marine, locomotive, areo, automotive and portable installations. The book was prepared by Julius Rosbloom, chief engineer, Unlimited, U. S. and officially endorsed by the United Licensed Officers, U. S. A.

The book is divided in two parts, both profusely illustrated and Part 1 includes discussion of heat, a form of energy, heat as applied to liquids, gases, liquids and their characteristics, oil in service requirements, oil storage and piping systems, valves, pumps for Diesel service, electrical subjects and simplified methods in practical calculation.

Part 2 includes the following chapter headings: Types and design of Diesel engines, engine operation, auxiliaries, marine practice, fuel and lubricating oils, accessories, electrical transmission, operating troubles and their causes, formulae and tables, indicator practice, Diesel trucks and automobiles, and points to remember.

The Diesel Hand Book can be secured through the Book Department, Gulf Publishing Company, Houston, Texas, Price $5.00.

"The Chemistry of Petroleum Derivatives"

CARLTON ELLIS, industrial research chemist, has given the petroleum industry another excellent reference work in his newest book, "The Chemistry of Petroleum Derivatives." The book is styled a monumental text and reference book in the field of organic chemistry, with special elaboration of derivatives of alipathic, naphthene, and unsaturated hydrocarbons isolated or derived from petroleum, and is the most up-to-date book on this important subject. Both the minor and major developments which have occurred in the application of petroleum as a raw material for the manufacture of chemical products are treated broadly and thoroughly, from both a theoretical and practical standpoint. The book, with its 1285 pages, is encyclopedic in scope, and is a veritable mine of information for organic chemists and technologists engaged in the development and utilization of natural gas and petroleum and their chemical derivatives. It will prove of real value to the student, research chemist, biologist, analyst, electrochemist, petroleum refiner, and the automotive, refrigeration and petroleum engineer. The work will prove of interest and value also to those engaged in the manufacture of hydrogen, acetylene, carbon black, alcohols, aldehydes, acids, ketones, glycols, emulsions, varnishes, lacquers, synthetic resins and rubbers, solvents, soaps, detergents, wetting and penetrating agents, textiles, beverages, explosives, dyestuffs, as well as motor fuels and other standard petroleum products.

Following are the chapter headings:

Introduction.

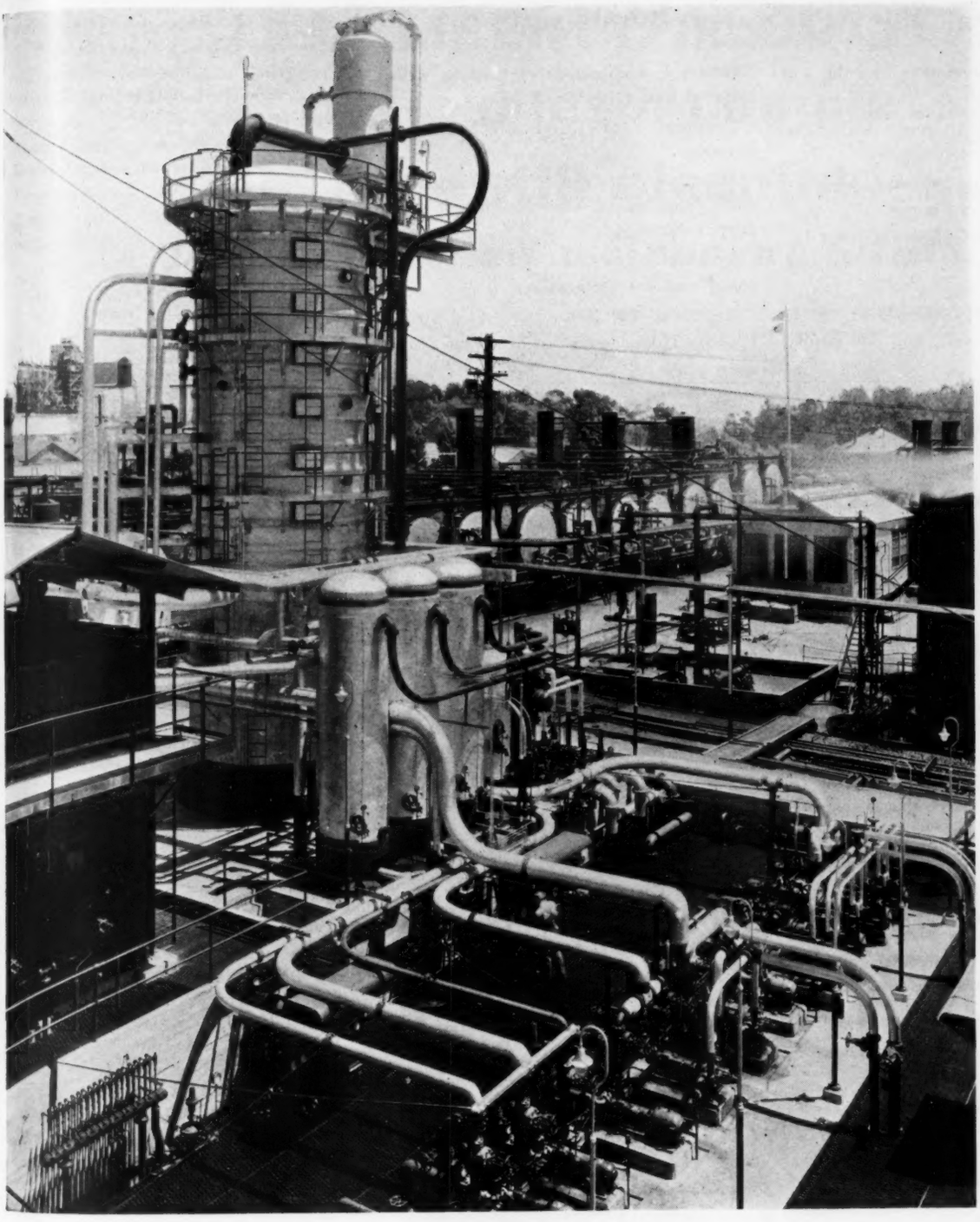
Chemical Nature of Petroleum and Natural Gas. Pure Hydrocarbons from Petroleum.

Thermal Decomposition of Hydrocarbons.

Cracking Processes and Their Products.

Production of Unsaturated Hydrocarbons by Pyrolysis—Olefins, Acetylene and Dolefins.

Production of Aromatic Hydrocar-



Lubricating Oils

This high vacuum distillation unit was recently put into operation for the production of lubricating oils. The capacity is 2500 barrels per day.

The tower is over 13 feet in diameter and fitted with three side streams, in addition to a small gas oil stream overhead. A barometric condenser and steam jet equipment provide the vacuum. A single contract for the installation included tubular oil heater, heat exchangers, controls, stack, foundations, instruments and complete accessories.

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Action of Aluminum Chloride on Hydrocarbons.

Production of Hydrogen and Carbon by Pyrolysis of Hydrocarbons.

The Carbon Black Industry. Deposition of Carbon from Flames.

Transformation of Hydrocarbons by Electrical and Other Special Forms of Energy.

Reactions of Hydrocarbons with Steam, Carbon Dioxide, and Ammonia.

Direct Hydration of Olefins to Alcohols.

Direct Esterification of Olefins with Mineral and Organic Acids.

Production of Ethyl Alcohol from Ethylene.

Reaction between Sulphuric Acid and Propylene. Production of Isopropyl Alcohol.

Properties and Uses of Isopropyl Alcohol and Its Derivatives.

Reaction of Sulphuric Acid with Higher Homologues of Ethylene and Propylene. Production of Higher Secondary and Tertiary Alcohols.

Properties and Uses of Higher Secondary and Tertiary Alcohols Derived from Olefins.

Production, Properties, and Uses of Ketones Derived from Secondary Alcohols and from Hydrocarbons.

Sulphur and Sulphur Compounds in Petroleum and Its Distillates. Their Occurrence, Chemical Properties and Possible Applications.

Reactions of Olefins with Halogens. Olefin Dihalides and Their Derivatives.

Production, Properties, and Uses of Halohydrins Derived from Simple Olefins.

Production, Properties, and Uses of Simple Glycols.

Production, Properties, and Uses of Olefin Oxides and Their Derivatives.

Miscellaneous Reactions of Olefins (I).

Miscellaneous Reactions of Olefins (II).

Polymerization of Monolefins and Diolefins. Production of Synthetic Rubber.

Some Important Reactions of Diolefins.

Important Reactions of Acetylene. Production of Acetaldehyde and Vinyl Esters.

Halogenation of Methane. Properties and Uses of Halogen Derivatives.

Halogenation of Methane Homologues. Properties and Uses of Halogen Derivatives.

Halogenation of Cycloparaffins.

Halogenation of Benzene and Its Immediate Homologues.

Production of Alcohols by Hydrolysis of Alkyl Halides. Production of Esters.

Miscellaneous Reactions of Halogen Derivatives of Paraffins and Cycloparaffins.

Extraction of Nitrogen Compounds from Petroleum.

Oxidation of Petroleum Hydrocarbons. General Considerations. Use of Air, Oxygen or Ozone.

Oxidation of Methane and Its Homologues.

Formaldehyde and Other Aldehydes.

Oxidation of Unsaturated Hydrocarbons.

Autoxidation of Petroleum Distillates. Gum Formation.

Oxidation of Aromatic Hydrocarbons.

Production of Acids from Petroleum Hydrocarbons.

Oxidation of Paraffin Wax. Production of Synthetic Fats.

Oxidation from the Standpoint of Detonation.

Miscellaneous Oxidation Reactions. Denaturants, Insecticides and Other Products.

Action of Sulphonating Agents on Pe-

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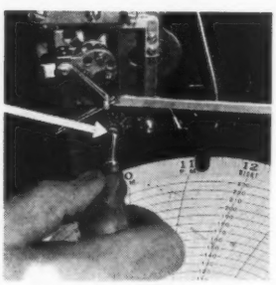

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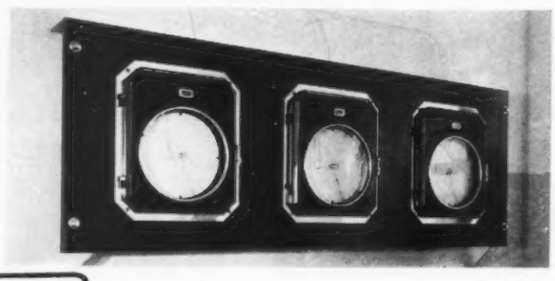

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Occurrence, Properties and Uses of Naphthenic Acids.

Analysis of Natural Gas and Cracking Gas.

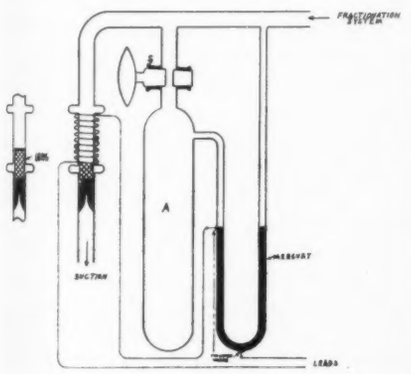
Methods of Analysis of Gasoline and other Petroleum Distillates.

Name Index. Subject Index.

Copies of The Chemistry of Petroleum Derivatives can be secured through the Book Department of The Gulf Publishing Company. Price $18.00.

Constant Pressure Regulator For Fractional Distillation

MUCH interest has of late been shown in the fractional distillation of liquids at low pressures, especially in the oil industry. In the quantitative fractionation of higher boiling liquids it is necessary that a low, constant pressure be maintained. This is usually done by means of mercury contacts actuating a relay which in turn



switches on or off the vacuum pump. This procedure of course results in excessive wear and tear on the pump, and better means of control were sought. A variety of means presented themselves but the most satisfactory was found in the use of an electro-magnetically operated valve. The accompanying diagram illustrates the regulator. The valve, as shown in the figure, consists of a large glass tube drawn to a solid, blunt point and ground to fit a small orifice in a constricted tube. An iron core is sealed or cemented inside the glass valve. It is necessary that the orifice be small in order that the pressure holding the valve down is not stronger than the attracting force of the solenoid. The size of the wire and the number of turns depend upon the size of the armature, the size of the orifice, and other factors and may easily be deter-

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The front section of the Type JH head is a freely swinging pivoted arm head. It engages and roughs out the coke no matter how heavy.

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The Liberty Type JH is thus really two heads in one,—and it does double duty. No need for using drills and universal joints in the tubes first. One trip through the tubes instead of two. Time saved, and the extra expense of drills. Self-feeding construction has been used on Liberty heads for many years.

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Pump room at Phillips Petroleum Company's Borger, Texas, refinery, installed for pumping fuel oil to rack 11 miles west of the plant. Motor driven triplex pumps are used.

mined by experiment. The magnet should be operated on low voltages so as not to necessitate the use of a relay.

With the stopcock S open, the system is evacuated until the desired pressure is reached. The stopcock is then closed. The mercury contact in the U tube is immediately broken and the valve falls, stopping evacuation. When the pressure rises the mercury again makes contact and the valve is pulled open. The pressure in the container A may be set at any value by closing the stopcock at the pressure desired.

In systems having large volumes, the regulator maintains a very constant pressure. In systems having small volumes, however, the sudden opening of the valve causes a jerk and rather large change of pressure. This may be remedied by regulating the suction flow with a pinchcock. With careful adjustment the pressure in small systems will vary only about one millimeter.—Eldon A. Meanes and Edward L. Newman, Wichita Testing Laboratories, Wichita, Kansas.

A. S. M. Technical Papers for Metal Congress

THOSE interested in metallurgical developments in the refining industry will find much of value at the sixteenth National Metal Congress to be held in New York, October 1-5, by the American Society for Metals. About 40 technical papers are scheduled for presentation and of this number 30 will be preprinted and ready for distribution about September 1. These papers, covering a wide range of subjects, will be presented at nine technical sessions. One of the features of the program will be a symposium on grain-size in steel, for which a dozen papers have been arranged. The annual meeting of the society will be held Wednesday morning, October 3.

Headquarters for the American Society for Metals will be maintained at the Hotel Pennsylvania. The National Metal Exposition, to be held simultaneously with the congress, will be housed in the Port Authority Building. At present 130 companies have engaged space, giving definite assurance that the show will be the largest for several years. Floor space required is already 25 percent in excess of that used last year.

Cooperating with the American Society for Metals and conducting technical meetings during the congress are the American Welding Society, American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers and the Wire Association.

Hydrogenation Planned in Japan

THE Department of Commerce and Industry, Japan, has secured an appropriation of 29,600 yen for encouraging the production of motor fuel from coal, according to K. Kitsuta, writing in the News Edition, Industrial & Engineering Chemistry, July 20. He states further that the plant of Hokkai Coal Hydrogenation Company has already started operating; Mitsubishi Mining Company is planning to establish a plant in Karafuto with a capital of 2,200,000 yen, the plant to use 10,000,000 tons of coal for low temperature distillation. An affiliate of the Mitsubishi concern owns and operates a large refinery in Japan in association with the Associated Oil Company. Nippon Electro-Industrial Company is also reported planning to build a hydrogenation plant in Karafuto with a capital of 30,000,000 or 50,000,000 yen; the company being now investigating methods of coal hydrogenation and low temperature distillation.

Distant Loading Of Heavy Fuel Oil

TRANSFERRING heavy fuel oil from storage tanks or from cracking units to tank cars is relatively a simple matter, but when this material must be pumped through a long line, the operation requires heavy machinery and much attention to operation and pipe line maintenance. Phillips Petroleum Company, at its Borger, Texas, refinery, produces a relatively heavy fuel oil, 225 Saybolt Furol viscosity, which congeals at relatively high temperatures. Loading this oil at the plant rack is no problem, but the bulk of it is transported to a rack on the railroad at Sanford, 11 miles west of the refinery.

The loading line from plant to rack is four inches in diameter, 1800-pound pipe, and is insulated by means of hair felt, protected with tar paper and buried. The oil when produced is picked up by a pair of Triplex pumps, size 4½ by 12, which operate at a discharge pressure of 500 pounds. In order to prevent the fuel oil from cooling below 150°F. a heating station was erected five miles west of the refinery. At this point the oil averages around 150°F. and it is again raised in temperature to 250°F. by means of a system of heat exchangers placed directly in the line. Steam is used as the heating medium. With this heating the oil arrives at the loading rack at an average temperature of 150°F.

Bleeder gates are placed at convenient points along the line, to be used in the event something occurs which stops the flow of oil. When operation of the line suddenly ceases, men are sent over the line to open the bleeder valves while the oil is hot. In the usual operating procedure, as soon as the required amount of oil has been pumped to the tank cars, hot water is immediately charged through the lines to flush out the oil.

The large triplex pumps handled 4,500 barrels of this fuel per day when in continuous operation. Each pump is driven by a 60 horsepower 440 volt, electric motor, driving the pumps through reduction gears.

A. P. I. Refining Division Proceedings Published

THE proceedings of the fourth mid-year meeting of the American Petroleum Institute, Division of Refining, held at Pittsburgh, May 22 to 24, 1934, are now being distributed. The 84-page booklet includes all papers and addresses delivered at the technical sessions of the division of refining, with the discussion following the presentation of each paper.

Included in the contents are two papers on the utilization of centrifugal apparatus in acid treating, one on percolation filtration, a paper dealing with the problem of viscosity of lubricants, one on the economic aspects of solvent refining and a discussion of fuels for spark-ignition and compression ignition solid-injection engines. These were presented under the session designated as "Refinery Problems."

Under "Automotive Problems" were papers on the economic aspect of high-octane gasoline, the relation of fuel octane number to engine compression ration, conservation of volatile gasoline fractions and butane—a wasted asset of the petroleum industry.

Reports of various committees are included in the report of the meeting of the general committee, Division of Refining.

Copies of the Proceedings, Vol. 15 M (111) (1934) can be secured from The American Petroleum Institute, 30 Rockefeller Plaza, New York, at 50 cents each.

National Independent Refiner's Association

THE newly formed National Independent Refiner's Association has opened offices in Washington, D. C., in the Southern Building, with C. R. Hoffer, El Dorado, Arkansas, in charge. This group is inviting partially integrated and non-integrated refiners and others, to participate in its activities, which, it is stated are to be for the purpose of providing refiners with kindred interests an opportunity to present a united front in treating with the code authority, the government and the industry in connection with the many problems faced at this time. Included in the organization of the associated are I. A. O'Shaughenssy, Globe Oil & Refining Company, Minneapolis; B. L. Majewski, Deep Rock Oil Corporation, Chicago; J. E. Shatford, Ouachita Valley Refining Company, El Dorado, Arkansas; Paul G. Blazer, Ashland Refining Company, Ashland, Kentucky; Dr. E. R. Lederer, Texas Pacific Coal & Oil Company, Fort Worth; J. A. Vickers, Vickers Petroleum Company, Wichita, Kansas; B. H. Gray, Spartan Refining Company, Shreveport; and J. K. Mahony, McMillan Petroleum Corporation, El Dorado, Arkansas.

Production of Crude for August

A DECREASE of 81,000 barrels daily in the national allowable production of crude oil was authorized by Secretary of the Interior Harold L. Ickes, the Oil Administrator, in fixing the August total of 2,449,300 barrels daily, as compared with 2,530,300 in July. The allowable becomes effective August 1.

The decrease resulted primarily from the stipulation by the Oil Administration in setting the August gasoline allocation at 36,270,000 barrels that gasoline inventories should be reduced 4,270,000 barrels in August. This action was necessary because the surplus in storage has been increasing recently, tending to hold back recovery. Crude oil production requirements are less-

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ened by this necessity for reducing stocks to balance the supply and consumer demand.

Virtually all the producing states shared in the decrease, with Texas' production lowered more than the others. Texas was reduced 40,800 barrels daily to 1,001,300. Other reductions: Arkansas, 2,600 to 30,400; California, 19,200 to 490,200; Illinois, 100 to 12,500; Kansas, 3,300 to 131,200; Kentucky, 1,400 to 11,700; Louisiana, 1,700 to 87,200; New York, 1,100 to 10,600; Ohio, 100, to 12,800; Oklahoma, 9,400 to 480,100; Pennsylvania, 3,300 to 40,700 and West Virginia, 700 to 11,600; Montana's allowable was increased from 8,000 to 8,800; Wyoming, 2,800 to 35,000 and New Mexico, 100 to 46,700. Colorado, Indiana and Michigan remained the same at 3,000; 2,300 and 33,200 respectively.

U. S. Acquires Large Helium Reserve

ACQUISITION of all gas rights in 50,000 acres comprising the Cliftside helium-bearing gas field near Amarillo, Texas, has been completed by the Bureau of Mines. This field supplies the raw material from which all helium used by the military services of the nation is extracted. In addition to supplying current requirements, the field provides a large reserve for future lighter-than-air craft operations by the army and navy. In five years operation, the plant has produced more than 57,000,000 cubic feet of helium, or about one half of all that element so far recovered. Officials estimate that the investment will be returned at a time when properties have served only a small percentage of their total useful life.

▼ PLANT ACTIVITIES ▼

Canning Plants: National Refining Company, Findlay, Ohio, and Coffeyville, Kansas, has let contracts for automatic canning equipment, one and five-quart operation, being installed in both plants.

Solvent Plant: National Refining Company at Marietta, Ohio, is installing a bright stock plant employing a solvent process controlled by company patents. Capacity 3000 barrels per month, to be in operation October 1.

Refinery: Cork Harbor Oil Wharves, Ltd., Haulbowline Island, Ireland, is mentioned in commerce reports as planning erection of a refinery with annual capacity of 3,000,000 gallons, to be erected under direction of Harold Moore, Sc., M.I.P.T. Lobitos Oil Fields, Ltd., and Anglo-Ecuadorian Oil Fields, Ltd., own stock in the enterprise.

Fractionating Unit: Barnsdall Oil Company, at its Avant, Oklahoma, gasoline plant, let contract to Petroleum Engineering, Inc., associated with Arthur G. McKee Company, for a fractionating unit to produce a wide variety of solvents and special products.

Recovery Plant: Cushing Oil & Refining Company, Cushing, Oklahoma, has let contract for a vapor rectification type of gasoline recovery plant to operate in conjunction with new cracking equipment being built. Contract to Petroleum Engineering, Inc., associated with Arthur G. McKee Company.

Chemical Plant: Solvay Process Company, a subsidiary of Allied Chemical & Dye Corporation, is building a completely integrated alkali plant at Baton Rouge, Louisiana. This is the third important new alkali plant under construction on the Gulf Coast, the other two projects being those of Mathieson Alkali Works, Lake Charles, Louisiana, and Southern Alkali Corporation at Corpus Christi, Texas.

Refinery: Trinity Petroleum Company, Ltd., Calgary, Alberta, Canada, is reported having plans prepared for a skimming plant.

Compressor Plant: Southern Natural Gas Company, Monroe, Louisiana, has awarded contract to Ford, Bacon & Davis, for natural gas compression plant.

Refinery: Compagnie Francaise de Petroles, operated through the French government, will complete construction of a new refinery at Berre, near Marseilles, in the spring of 1935.

Refinery: American Oil Refining Company, headed by Phillip Meyrowitz, Hynes, California, has completed erection of a small skimming plant.

Change Name: Envoy Petroleum Company is the new name for the D. R. Wilson Refining Company, Signal Hill, California, and the company is now owned by the Lockhart brothers, formerly identified with Rio Grande Oil Company.

Operating: Mid-West Refineries, Inc., is now operating its recently completed 2000-barrel skimming plant at Alma, Michigan.

Solvent Plant: Standard Oil Company of Louisiana, Baton Rouge, is reported completing construction of a 3000-barrel capacity Phenol solvent refining process.

Improvements: Quaker State Oil Refining Corporation, at its McKean County plant, has enlarged wax pressing department through installation of additional pressing facilities. New fire pump house and fire pumps being installed.

Refinery: Henry Goodman and I. E. Goodman, formerly president and treasurer, respectively, of Keystone Oil Refining Company, Detroit, Michigan, have acquired a 43-acre site at New Boston, Wayne County, Michigan, on the Huron River and Pere Marquette Railroad, where they plan construction of a 2000- to 3000-barrel topping plant, with ultimate plans including a cracking unit. Temporary engineering offices have been opened at 828 Farwell Building, Detroit.

Refinery: Old Dutch Refining Company, operating a refinery at Muskegon, Michigan, is reported planning erection of a second plant at Edmore, Michigan.

Refinery: Max Bray recently announced plans for construction of a refinery in the new Montcalm County Traverse producing area, Michigan. To move equipment from Texas.

Chemical Plant: Carbide and Carbon Chemicals Corporation, 30 East 42nd Street, New York, and South Charleston, West Virginia, is having plans prepared by R. N. Shepard, chief engineer, for a chemical plant at Whiting, Indiana. Reported cost $5,000,000.

Refinery: R. W. and Max Lewis, Ovid, Michigan, are reported planning construction of a refinery at Elsie, Michigan. Estimated cost $60,000.

Refinery: Champlain Oil Company, Pointe aux Trembles, Quebec, Canada, is reported planning construction of a 2500-barrel refinery, on 23rd Avenue. Estimated cost $350,000.

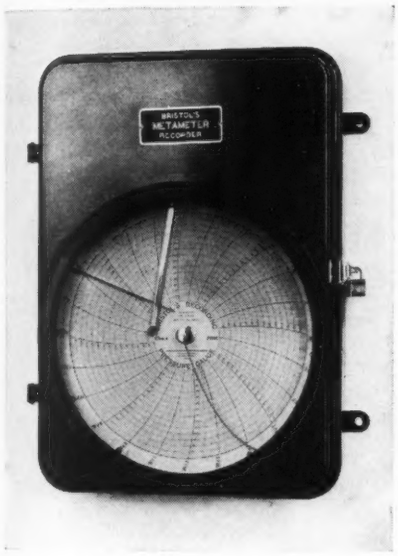
Standard Oil Company (Indiana) has appointed Dr. O. E. Bransky, former manager of its Whiting, Indiana, refinery, to the position of assistant general manager of manufacture at Chicago. Dr. E. J. Shaeffer succeeds to the position of manager at Whiting.

New Equipment for the Modern Plant

Recording Pressure Gauge

THE BRISTOL COMPANY

The Bristol Company, Waterbury, Connecticut, announces a new direct reading absolute pressure gauge of the recording type. The instrument is a recording vacuum gauge which is compensated for changes in barometric pressure and for changes in temperature, and therefore reads direct in absolute pressure. The instrument is equipped with two measuring elements



Bristol Recording Pressure Gauge

which are co-ordinated through special differential transmitting linkage. One measuring element is connected to the vacuum line and the other functions in connection with the compensating features of the recorder. The instrument is furnished for ranges as low as 25 millimeters head of mercury absolute pressure or its equivalent. It is available in rectangular form case of wall type or flush type design.

Calorimeter

THE HAYS CORPORATION

The Hays Corporation, Michigan City, Indiana, has announced the Hays Portable Calorimeter which was developed for determining the B. t. u. content of gas, amount of combustibles unburned in whole gases, explosive limits of gases, explosive properties of sewage and mine gases, heating value of gaseous mixtures too lean to ignite in air alone and correct setting for gas burners. The manufacturer claims these determinations may be found in from one to five minutes.

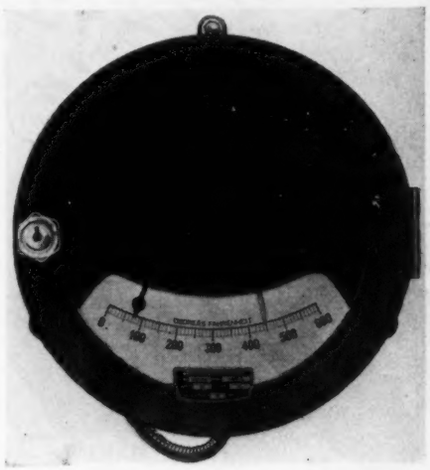
The calorimeter contains an explosion burette of approximately 100 cubic centimeters capacity, having an etched scale with a division line for tenth cc. Upper end of the explosion burette carries a three-way cock, through which gas and air are admitted. The burette is equipped with platinum electrodes which serve to explode the gas mixtures, and also for the electrolytic generation of oxy-hydrogen.

Thermometer Controller

THE BROWN INSTRUMENT CO.

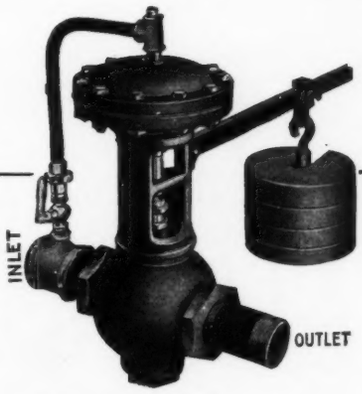
The Brown Instrument Company, Philadelphia, Pa., announces the use of mercury switches to eliminate open make-and-break contacts as a feature of a new Automatic Control Indicating Thermometer. In new controller, every six seconds a motor-driven control table determines the location of the pointer in reference to the control setting, and tilts the mercury switch from one side to the other if the temperature has changed.

With this system, the measuring mechanism is free to position itself,



Brown Thermometer Controller

unhampered by the control mechanism. There is no excess weight on the pointer, no distortion or restriction of pointer movement. The making of control contacts is not dependent upon friction, because the switch is positioned with a positive action by the electric motor. Contacts are unaffected



CF

COMPRESSOR
REGULATOR

Speed Pump

Regulation Made Definite and Sure

EXCESS discharge pressure is relieved, discharge kept constant, and operation of the compressor at full speed made safe, by use of the C-F Compressor Regulator. As a close regulator of pressure on electric-driven pumps, it stands unrivalled. Gas, steam, air, water—in all such applications the C-F Compressor is thoroughly dependable. The lever type is here shown. A spring loaded valve is also available and is equally sure in operation. Excess discharge pressure flows through without noticeable variation in suction line. Ask for descriptive pamphlet No. 130, also Catalog of Chaplin-Fulton regulators for all requirements of gas-pressure control.

The Chaplin-Fulton Manufacturing Co.

28-40 Penn Avenue **Pittsburgh, Pa.**

"BREAKING OUT"
Pull tong back to engage forward teeth and lift up.

"MAKING UP"
Engage rear teeth and push down.

PUSH DOWN! That's all you have to do to "make up" pipe with Williams' "Vulcan Boll-Weevil" tongs.

"Vulcan Boll-Weevil"—the REVERSIBLE tongs—are designed for pipe line and general work. Easy to use; you simply lay the tongs on top of the pipe, hook chain around it, and you are ready to "make up" or "break out" pipe.

"Vulcan Boll-Weevils" are fitted with Reversible Jaws providing double life. Chains are proof-tested and CERTIFIED, and are positively self-releasing.

Four tong sizes for ¾ to 12″ pipe. Buy from your distributor.

J. H. WILLIAMS & CO.
"The Drop-Forging People"
75 Spring St. New York

Western Warehouse and Sales Office, Chicago Works, Buffalo, N. Y.

NRA MEMBER U.S. WE DO OUR PART

EXTRA FLAT CHAINS *for the four patterns of Williams' "Vulcan" Tongs are interchangeable, size for size.*

WILLIAMS
SUPERIOR DROP-FORGED TOOLS
VULCAN BOLL-WEEVIL REVERSIBLE TONGS

by vibration because the mercury switch is mechanically locked in place until a different position is required. These mercury switches have capacities up to 15 amperes at 110 volts (10 amperes at 220 volts), thus eliminating external relays in most applications.

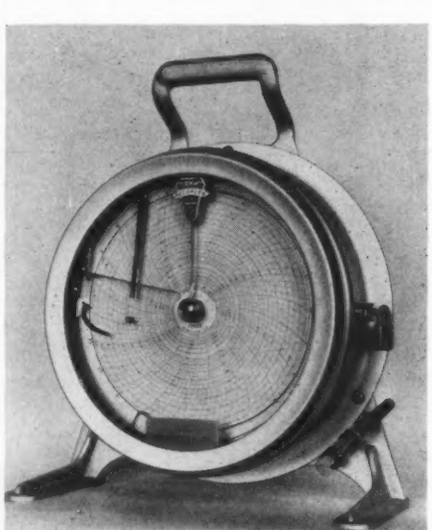
All models of this controller are furnished in circular 10-inch universal cases and offer all the outstanding features of the new Brown recording thermometer and pressure gauge.

This new indicating controller is equally adaptable for control of pressure, liquid level, and similar factors, as well as temperature.

Portable Recording Thermometer

THE FOXBORO COMPANY

The Foxboro Company, Foxboro, Massachusetts, announces a new lightweight, portable recording thermometer, for convenient use where temperature must be checked periodically. A companion instrument with like features is also made for recording pressures. The chart is easy to remove and the chart disc can be removed without the use of screw drivers, as the sliding wedges provided make the interior of the instrument easily accessible. The portable model is provided wth either self contained or long distance type thermometers in eight- or 10-inch



Foxboro Portable Recording Thermometer

cases. The illustration shows a 10-inch self-contained Class 11 instrument with a range of —25° to 125°F. It is provided in frosted silver or dull black lacquer finish. The portable models can be removed from the stands by unscrewing three bolts and the instruments can then be fastened on a wall or board for permanent use if desired.

Gate Valve

KENNEDY VALVE MANUFACTURING COMPANY

The Kennedy Valve Manufacturing Company, Elmira, New York, announces a new heavy standard bronze gate valve designed for 150 pound working steam pressure and 250 pound working water, oil or gas pressure.

Kennedy Valve

This valve, has all the special features of design which were recently incorporated in the Kennedy standard bronze gate valve but is heavier throughout to withstand the higher working pressures for which it is intended.

One of the features of these new valves is the large bonnet hex which is placed close to the body to make the entire valve more rigid and also to assist removal of the bonnet and stem assembly when the valve is installed with close clearances.

Another feature is the design of the stem which is made of specially tough bronze, has a large number of heavy contact threads, and has a flexible connection between the stem had and the disc, making stripping of threads almost impossible and prolonging the life of the valve.

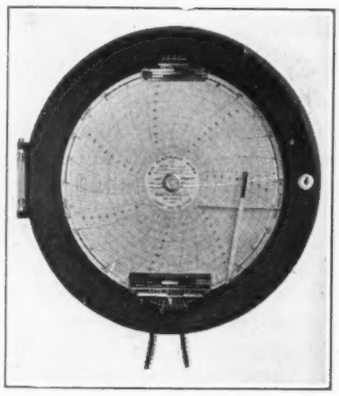
Other features are the deep stuffing box with specially selected high graphite molded packing rings, bronze gland and heavy packing nut, the substantial non-heating non-slipping handwheel, and the heavy pipe end hexes. These valves are built in a complete range of sizes up to three-inch.

Electric Flowmeter

MOREY & JONES, LTD.

Morey & Jones, Ltd., 922 South Hemlock Street, Los Angeles, announces a new instrument, "Electro-flo," a flow meter built on the induction balance principle for measuring the flow of liquids. The meter combines in a single unit an indicator, recorder and totalizer, all of which are direct reading.

The mercury manometer and split coil sending device are similar in principle to the usual flow meter of this type. The receiving unit differs in that there are two cores, which when in the same relative position indicates a balanced circuit and the relay is centered. When one core moves the relay becomes unbalanced, operating the motor in such a direction as to the cam and return a second core to a position relatively comparable to that of the first core. When this position is reached the circuit is again balanced and the motor stops.



Morey & Jones Electric Flow Meter

The cam extracts the square root of the differential pressure and thus gives an evenly divided flow scale. The scale attached to the cam serves as a flow indicator and also operates the pen arm. A simple motor driven mechanism operates the integrator. The integrator motor runs during each half minute for a time directly proportional to the rate of flow.

Portable Compressor

INGERSOLL-RAND COMPANY

Developed particularly by Ingersoll-Rand Company, New York, N. Y., for service in the oil and gas fields, where pressures are high and requirements are exacting, the Type XL Portable Compressor is made in two sizes, one for 300 pounds operating pressure (and 500 pounds starting pressure), the other for 500 pounds operating pressure (and 1000 pounds starting pressure). Piston displacements are, respectively, 330 and 270 cfm.

The Type XL Portable Compressor is a combination of either the I-R Type H oil engine or the Waukesha gasoline engine with the well-known I-R Type XOB horizontal, double-acting compressing cylinders, of which more than 2000 are now in service. The Type XOB cylinder is used in several types of I-R compressors for gas-lift service.

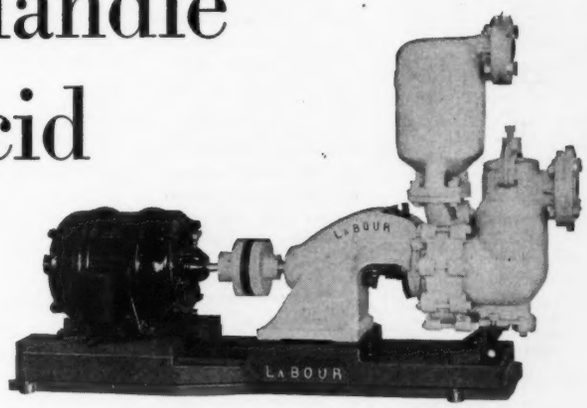
The complete Type XL Portable Compressor, with fuel tanks and receiver, is mounted on a one-piece, cast-steel frame, equipped with rubber tires and steel wheels, fitted with roller bearings. The steel top has removable steel side covers arranged for locking.

Metameter System

THE BRISTOL COMPANY

The Bristol Company, Waterbury, Connecticut, has available a new long distance transmitter and recorder operating on the chrono-flo system. Adapted to Bristol's Metameter, this system consists of a transmitter, a recording receiver, a relay and rectifier box at the receiver, and a two-wire line connecting the transmitter and receiver. With this system, records of temperature, pressure, liquid level or motion may be transmitted great distances, 250 miles or more, with ac-

The *Economical* Way to Handle Acid



LaBour

Economy of time, of labor, and of maintenance costs follows the installation of LaBour pumps for handling corrosive liquids in refineries. Available in self-priming or gravity feed types, they start to move liquid promptly and certainly whenever they are called upon. The self-priming type provides extraordinary safety due to the fact that much of the line can be at less than atmospheric pressure. The hazards of bottom outlets and gravity feed are completely excluded.

The simple, rugged design of LaBour pumps makes them reliable. There is but one moving part —the impeller—and there are no valves, floats or other troublesome accessories. Time-out for repairs or replacement is down to the minimum when you use LaBour pumps.

Let the experience of the LaBour organization help you. This organization has long specialized in the problems involved in handling and conveying liquids in process plants. You'll be under no obligation or cost in asking for full information.

THE LABOUR CO., INC. 807 STERLING AVENUE ELKHART, IND.

ORIGINATORS OF THE SELF-PRIMING CENTRIFUGAL PUMP

55 Years of Dependable Service

K&M Products

Standard equipment for many years with leading refineries and industrial concerns, Kieley & Mueller Products will well repay your most thorough investigation.

The high standards set and the rigid tests made in their manufacture, have resulted in long years of dependable service. Many K & M installations of thirty and more years are still delivering unfailing performance.

May we have the pleasure of quoting on your next requirements?

Write for Bulletins on products in which you are interested.

VALVES

Pressure Regulating, Air Pilot Operated, Balanced, Back Pressure Types.

LIQUID LEVEL CONTROLLERS

Internal or external types; direct or remote control; for either vacuum or pressure.

STEAM TRAPS

Inverted Bucket type; large capacity, small size. Quick acting. Sizes 3/8" to 2".

PUMP GOVERNORS

Diaphragm, piston and air actuated; in various metals for all liquids.

KIELEY & MUELLER, Inc.

Main Office and Warehouse:
34 W. 13th St., New York, N. Y.
Plant: Newark, N. J.

KIELEY & MUELLER

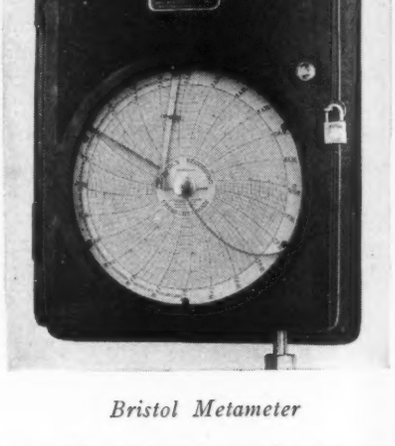
PRESSURE AND LEVEL CONTROL APPARATUS

curacy and with freedom from circuit disturbances.

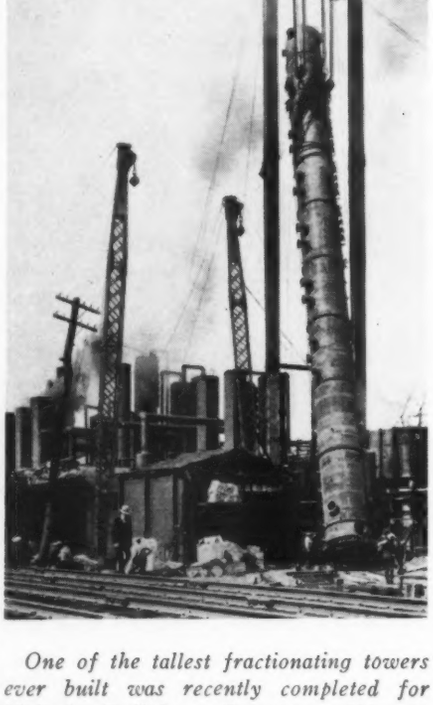
The principle of operation is as follows: The transmitting element detects the measurement and translates it into a time function. By this means, the two-wire circuit carries an impulse during a portion of a fixed time interval and is broken for the remainder of the interval. This time interval is provided by a synchronous motor-driven continuously-rotating cam. The time that the circuit is made during each rotation of the cam is proportional to the amount the condition being measured has risen above the base or zero measurement. Conversely, the duration of contact off is proportional to the amount the condition has dropped below the maximum amount.

These messages of circuit made and circuit broken are translated by the recording receiver into upward or downward movement of a pen positioning mechanism, thereby periodically carrying the pen arm to its new position as measured by the transmitter.

This system requires a source of alternating current at both receiver and transmitter, but they need not be synchronized, nor of the same frequency. The recording receiver uses a 12-inch chart and is housed in a moisture-proof rectangular case.



Bristol Metameter



One of the tallest fractionating towers ever built was recently completed for United Refining Company, Warren, Pennsylvania. This tower is six feet nine inches in diameter and 110 feet high. It was constructed entirely by arc welding and shipped in one piece weighing 80 tons. The tower was welded by The Struthers-Wells Company, using the shielded arc process with equipment manufactured by The Lincoln Electric Company.

Compressors

ROOTS-CONNERSVILLE BLOWER CORPORATION

Roots-Connersville Blower Corporation, Connersville, Indiana, announce the addition of a single-stage type "OIB" unit to its line of centrifugal compressors and exhausters. In this design the machines have their own shafts and bearings and are suitable for direct connection to standard electric motors or steam turbines, without special shaft extensions. They are also adaptable to V-belt or flat belt drive.

Impellers are furnished in aluminum or carbon steel in the standard construction, but special alloys are supplied where conditions require. Open type impellers are used in the smaller sizes, with closed type for the larger machines. Casings are ordinarily made of cast iron, but special aloys, to resist corrosion or abrasion, can be supplied. These units are said to have sturdy bearings stands that fit them for heavy duty service in a wide variety of applications. Anti-friction bearings are used in the smaller sizes and sleeve bearings in the larger units.

Electric Motor

STERLING ELECTRIC MOTORS

Sterling Electric Motors, Los Angeles, California, has added a new upright enclosed design to its line of vari-speed electric motors. This is an addition to the vari-speed, horizontal type announced a few months ago. The upright type is available in ratings up to 15 horsepower.

Items About Manufacturers

The Duiron Company, Dayton, Ohio, manufacturere of acid and alkali handling equipment is constructing an extension to its alloy steel foundry which doubles the size of the old plant.

Garrison Engineering Corporation, 21 East 40th Street, New York, has appointed W. L. Walker Company, 800 South Main Street, Tulsa, as its sales representative in the Oklahoma and Kansas district in extending the Garrison DuGas fire control service.

William E. Umstattd, formerly executive vice president of Timpkin Roller Bearing Company, Canton, Ohio, has been elected president of the company, to succeed H. H. Timpkin, who resigned but continues as chairman of the board. Henry H. Timpkin, Jr., was elected a vice president of Timpkin Steel & Tube Company.

Kenneth M. Leach, of Audley Engineering Company, Ltd., Newport, Shropshire, England, who has been in the United States for some time visiting factories of Merco Nordstrom Valve Company and Pittsburgh Equitable Meter Company, was recently joined by his father, R. W. Leach, chairman of the board of Audley Engineering Company. This concern is closely affiliated with Merco Nordstrom and is licensed to manufacture "Audco" lubricated plug valves for Europe and Asia.

O. E. Berg has been made district sales manager in the southwestern territory for Allegheny Steel Company, Brackenridge, Pa., and is establishing district headquarters in Houston.

Sivyer Steel Casting Company, Milwaukee, Wisconsin, announces opening of an eastern office in charge of A. N. Diecks, Suite 810, 500 Fifth Avenue, New York. The office will specialize in the products of the Refinery Division, consisting of steel return bends, special refinery fittings, alloy tube supports, and Sivyer stainless steel casting for refinery use.

Filtrol Company, Los Angeles, is completing installation of new buildings and new machinery at its Los Angeles plant for increasing production of its activated clays by 50 percent.

Allis Chalmers Manufacturing Company, Milwaukee, announces removal of its Chicago district office to the new Field Building, 135 South LaSalle Street. B. F. Bilsland is manager of the Chicago district.

The Edwards Valve & Manufacturing Company, East Chicago, Ind., announces appointment of McGregor Engineering Company, of Tulsa, as representative in Oklahoma, northern Arkansas and the Texas Panhandle.

Republic Steel Corporation, Youngstown, Ohio, announces appointment of Stanley A. Knisely, of Cleveland, as advertising and sales promotion manager, with headquarters at Youngstown. He succeeds L. S. Hamaker, who was recently made vice president and general manager of Berger Manufacturing Company, Canton, a subsidiary of Republic Steel Corporation.

The Brown Instrument Company, Philadelphia, announces the appointment of L. Morton Morley as general sales manager. He will have complete supervision of all sales, advertising and sales promotional activities. He was formerly district manager of the Philadelphia office and has been associated with the company for the past 15 years.

Harlowe Hardinge, vice president and general manager of Hardinge Company, Incorporated, York, Pennsylvania, has recently returned from Europe where he has been actively engaged in handling matters in connection with foreign interests of the company.

The Louis Allis Company, announces that its Pittsburgh office has been moved to 537 Oliver Building, with J. F. Rodgers in charge.

The United States Stoneware Company, Akron, Ohio, announces that it has received a manufacturing and selling license from the Hills-McCanna Company, Chicago, to manufacture the Saunder Patent Diaphragm Valves with chemical stoneware bodies.

L. S. Hamaker, sales promotion manager of Republic Steel Corporation, Youngstown, Ohio, has been advanced to the position of vice-president and general manager of The Berger Manufacturing Company, Canton,

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Oxy-Acetylene Welding

The Linde Air Products Company, 30 East 42nd Street, New York, has issued a new illustrated eight-page booklet "101 Uses for the Air Acetylene Flame." A second booklet offered is "The Maintenance of Reciprocating Parts." Both are valuable additions to the literature on oxy-acetylene welding.

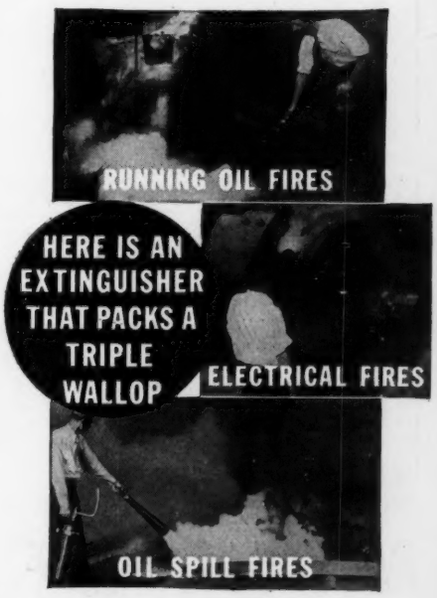
Who will Bet on a One-Armed Fighter?

SOME fire extinguishers, like a one-armed fighter, have only one punch. They will put out only one kind of fire.

LUX extinguishers, however, pack a triple wallop against the fires that most frequently occur at refineries and bulk plants. They put out fires in oil and gasoline spills on the ground, fires in oil pouring from a cracked fitting or overflowing tank truck and fires in electrical apparatus. No other type of extinguisher is effective against all three.

That is one reason why leading oil companies are adopting LUX. Other reasons are that LUX extinguishers require refilling only when used and will not freeze in the coldest winter weather.

You can't tell beforehand what your next fire will be. But with LUX, you will have protection against three kinds of fire instead of one. May we send you descriptive literature? Walter Kidde & Company, Inc., Dept. B-8, Bloomfield, New Jersey.



LUX EXTINGUISHERS

For Refineries—Bulk Plants—Trucks

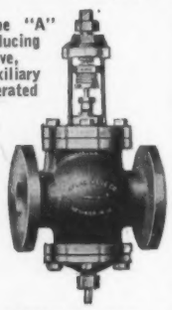
Make it Your
HABIT

to put all regulating problems up to ATLAS engineers. It will be a *good* habit. Solving such problems has been our specialty for more than 30 years.

☐ CAMPBELL Boiler Feed Water Regulator
☐ Reducing Valves
☐ Damper Regulators
☐ Temperature Regulators
☐ Pump Governors
☐ Balanced Valves
☐ Control Valves
☐ Float Valves
☐ Swing Joint Fittings
☐ Thermostats

Check carefully the list at the left, of ATLAS Refinery Regulating Devices. Clip out. Attach to your letterhead. Mail to us. We will send complete information promptly.

Type "A" Reducing Valve, Auxiliary Operated



ATLAS VALVE COMPANY
REGULATING VALVES FOR EVERY SERVICE
275 South St., Newark, N. J.

Now Is the Time

TO RE-COVER YOUR FILTER LEAVES WITH LONG LASTING

SMOOTH-TEX
METALLIC FILTER CLOTH

You can do the work, using our improved method and fittings or we do it for you.

Write to-day

MULTI-METAL WIRE CLOTH CO., INC.
795 EAST 139TH ST.
NEW YORK, N. Y.

Ohio, wholly owned subsidiary. Hamaker began his career in the steel industry in the sales department of The Berger Manufacturing Company and later was made advertising manager. During a series of mergers he became advertising manager of United Alloy Steel Company, Central Alloy Steel Corporation, and finally of Republic Steel Corporation, when that organization was formed. He was appointed sales promotion manager of Republic Steel Corporation in 1931.

Anglo-American Chemical Corporation, Philadelphia, Pa., has taken over the manufacture and sales of certain chemical products formerly sold by American Chemical Products Co., Rochester, N. Y. These chemical bases when blended with mineral oil or grease convert these oils into products of high load carrying capacity, popularly known as extreme pressure lubricants. These bases, as well as improved modifications of the same, will now be sold under the name "Anglamol," and are made in grades to suit any type of oil or grease. They can be mixed cold and go into solution without any expensive blending operations. It is claimed that only four to eight percent are required to convert any oil into an extreme pressure lubricant which will meet the full load, full speed requirements of any of the commonly known testing machines.

The offices and laboratories of Anglo-American Chemical Corporation are located at 801 Hardt Building, Broad St. at Columbia Ave., Philadelphia. The officers of the new corporation are: President T. L. Holland, vice president Victor A. Ryan, treasurer Dr. R. H. Patch, secretary M. Ryan.

Allis-Chalmers Manufacturing Company announces appointment of W. R. Judson as manager of the Salt Lake City district office, located in the Kearns Building, Salt Lake City, Utah. For the past three years Judson has been managing director of Allis-Chalmers (France), representing Allis-Chalmers Manufacturing Company in Europe. Prior to that time, for 13 years, he was manager of the company office at Santiago, Chile, covering Chile, Peru, and Bolivia. In Salt Lake Mr. Judson succeeds H. E. Weiss, who has been transferred to the company's office at Kansas City.

George H. Bucher was elected president of the company at a recent meeting of Westinghouse Electric International Company. Bucher has been connected with the Westinghouse organization since September 1, 1909. After graduating from Pratt's Institute, Brooklyn, New York, in both steam and machine design, and also electrical engineering, he joined Westinghouse Electric & Manufacturing Company at East Pittsburgh as a graduate student. In 1911 he was transferred to the export department at New York and in 1920 he was appointed assistant to the general manager of Westinghouse Electric International Company; and in 1921 he was promoted to assistant general manager and in 1932 to vice president and general manager of the same company. He is a member of the American Institute of Electrical Engineers, Engineering Club and Lawyers' Club.

Volcano Burner Company, Tulsa, announces appointment of Henry H. Paris, Houston, Texas, as distributor for its products in the Gulf Coast. Paris has warehouse facilities and offices at 1121 North San Jacinto Street.

McCormick Asbestos Company, 1400 Block, Moreland Ave., Baltimore, Maryland, has been appointed agents for the Baltimore territory by Mundet Cork Company, 450 Seventh Ave., New York City, manufacturers of Mundet "Jointite" cork board for cold storage purposes and roof insulation; cork pipe covering for low temperature lines, lagging, floor tile, board, cork isolation against machine vibration, etc.

PULMOSAN RESPIRATORS for EVERY NEED
Protection against DUST SPRAY MISTS SANDBLASTING
WRITE for DETAILS
PULMOSAN SAFETY EQUIPMENT CORP.
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A.S.T.M.-C.F.R. OCTANE RATINGS
Natural Gasoline and Gas Analysis
Using Podbielniak apparatus.
All other tests on Petroleum Products.
Phoenix Chemical Laboratory
"an exclusive petroleum testing laboratory"
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Electrically Driven Centrifuges
Hand Centrifuges
WRITE
WILLIAMS, BROWN & EARLE, Inc.
Manufacturers of Laboratory Apparatus
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